CR 151677

DOC. TYPE 2
DATA CAT. SE

JSC-12033
15 FEBRUARY 1978

Spacelab Uplink/Downlink Data Flow and Formats

(NASA-CR-151677) SPACELAB UPLINK/DOWNLINK DATA FLOW AND FORMATS (Ford Aerospace and Communications) 388 p HC A17/MF A01 CSCL 17B

N78-22267

Unclas

G3/32 15634

Contract NAS 9-15014

Prepared for
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center

Ford Aerospace &
Communications Corporation
Space Information Systems Operation

Doc. Type 2
Data Cat. SE

CR 151677

JSC-12033
Change 3
22 March 1979

SPACELAB UPLINK/DOWNLINK

DATA FLOW AND FORMATS

Contract NAS 9-15014

DRL LI 5

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

Submitted by: S. Stanley

Approved by: G. O. Nossaman
G. O. Nossaman, Supervisor
System Analysis Section

Approved by: C. H. Denny Jr
C. Denny, Manager
Computer Systems Department

Approved by: R. E. Gantz
R. E. Gantz, Manager
MCC OFTDS Program Office

FORD AEROSPACE & COMMUNICATIONS CORPORATION
SPACE INFORMATION SYSTEMS OPERATION
1002 GEMINI AVENUE
HOUSTON, TEXAS

FOREWORD

This study was authorized by TA A-2E29 under TO A-2E00.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

TABLE OF CONTENTS (CONT'D)

TABLE OF CONTENTS (CONT'D)

TABLE OF CONTENTS (CONT'D)

LIST OF FIGURES

LIST OF FIGURES (CONT'D)

LIST OF FIGURES (CONT'D)

LIST OF TABLES

SECTION 1

INTRODUCTION

1.1 PURPOSE

This document presents the results of an analysis of the Spacelab (SL) data uplink/downlink structure and those data system elements associated with the support of this data flow. An end-to-end approach is used to describe the data and data systems from the data source to its destination; i.e., telemetry data originating in experiments and subsystems onboard SL are followed through the SL data acquisition and handling subsystem, through signal processing for radio frequency link transmission, through the Tracking Data Relay Satellite System (TDRSS) element, and finally to the Payload Operations Control Center (POCC) at JSC. Similarly, commands originating in the POCC are followed through the Space Transportation System Mission Control Center (STS MCC), the TDRSS element, the STS Orbiter, and to their destination onboard SL.

Specific objectives of this report are to present the results of the following analyses in order to provide ground data systems designers with sufficient knowledge of SL systems and data formats to perform a preliminary POCC design.

- Operations of the SL high-rate multiplexer, including format structure, data rates, format combinations, format switching, etc.
- Operations of SL data recorders to include the definition of modes, data rates and forms
- Operations of the high-rate demultiplexer as described above
- Potential experiment data formats defining formatting parameters to be considered in decommutation analysis
- SL computer input/output (I/O) decommutation channels, including the definition of structure, quantity and use of this I/O data
- Detailed requirements of the data quality monitoring philosophy for this function.

1.2 SCOPE

This study addressed only those data and data systems elements unique to or associated with the SL flights. Independent experiment downlinks from a SL configuration are not considered in this issue because the link characteristics are not available at this time. The elements and formats of the payload data interleaver are not included since the interleaver is not present in a spacelab configuration.

Parameters used in the descriptions of the data and systems are those which best assist, directly or indirectly, in the subsequent design definition of the JSC POCC.

Much of the data presented must necessarily be considered preliminary, since many experiments and SL design issues are open. Updates to this document are TBD. However, this document should represent the latest information available. An indication of the availability of updated data is given by the relevant major milestones from the MSFC Spacelab Payload Mission 1 Master Schedule, figure 1-1.

Figure 1-1 deleted

(Refer to JSC-11640, Vol. II,
*MCC Integration Plan for
Shuttle Orbital Flights)*

1.3 DOCUMENT ORGANIZATION

This report is a working document, with information relevant to each task group organized under stand alone headings. The descriptions of system elements address the routing/formatting of experiment data, and the requirements that are imposed on ground-based systems by the data/command flow conventions of the Spacelab and data network. The data included is intended to provide POCC task personnel with sufficient knowledge of Spacelab system elements to proceed with tasks in their areas of responsibility.

The main body of the report contains a summary-level description of the major information categories: functional description of Spacelab elements, Orbiter/Spacelab telemetry data flow, Orbiter/Spacelab command data flow, and high rate demultiplexer telemetry formats.

SECTION 2

OVERVIEW

The primary concerns of this report are the data flows associated with experiment telemetry and Spacelab/experiment commands. The major factors affecting these data flows are the Spacelab elements, STS interfaces, communication links, and existing JSC Orbital Flight Test (OFT) equipment and operational philosophies. To address these factors, the report has been organized to first discuss the Spacelab elements and STS interfaces which affect the acquisition multiplexing and routing of experiment data, and then to discuss the end-to-end telemetry data and command flow through the defined system.

The main body of this report has been prepared to a summary level of description. Specific areas which require detailed descriptions to meet the requirements of Tasks TA A-2E30 and TA A-2E31 have been incorporated into appendices of this document.

2.1 DESCRIPTION OF SPACELAB/ORBITER ELEMENTS

2.1.1 Spacelab Elements. The Spacelab subsystem central to telemetry and command flow is the Command and Data Management Subsystem (CDMS). The CDMS provides a variety of services to Spacelab experiments and subsystems. These services include:

- Data acquisition
- Data processing
- Data formatting
- Data transmission
- Recording
- Large volume bulk storage
- Monitoring
- Display
- Command and control capability for experiments

- Command and control capability for subsystems
- Audio intercommunication
- Caution and warning
- Provisions for closed circuit television.

Figure 2-1 presents a functional block diagram of the CDMS. It shows the location of CDMS equipment for the module-plus-pallet mode, and for the pallet-only mode, using the igloo.

Experiment outputs delivering housekeeping and low-speed scientific data that needs further onboard processing are sampled by remote acquisition units (RAU's) and transferred to the experiment computer via interconnecting stations (IS's), the experiment data bus, and the experiment input/output (I/O) unit.

On the same path, serial pulse code modulation (PCM) and ON/OFF commands are transferred from the experiment computer via the RAU's to the experiments.

The RAU user time clock (UTC) delivers precision reference timing information.

Typical functions for onboard processing of scientific data by the experiment computer are quick-look analysis, data compression, etc. Programs for control and processing of experiments and subsystems exceeding the storage capability of subsystem and/or experiment computer can be loaded at execution time from the mass memory unit (MMU).

A backup computer, which is primarily intended as backup for the subsystem (S/S) computer, is also available to experiments in case of experiment computer failure. The backup computer is normally filled with subsystem programs. Before operating as an experiment computer, the core memory has to be loaded with the appropriate experiment software from the MMU.

The subsystem and experiment branches of the CDMS are identical and are composed of the same components, (computer, I/O unit, data bus, and RAU modules) except for the UTC capability, which is unique for experiments. However, it should be noted that there is no direct link between the subsystem and experiment branch.

Experiment and subsystem monitoring and control is performed by crew and ground personnel through the CDMS equipment. Command functions are initiated automatically through preprogrammed computer sequences stored in the MMU, or semiautomatically by interaction of the keyboard data display unit (DDU) with the computer, or by telecommands through the Orbiter uplink (2 kb/s).

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

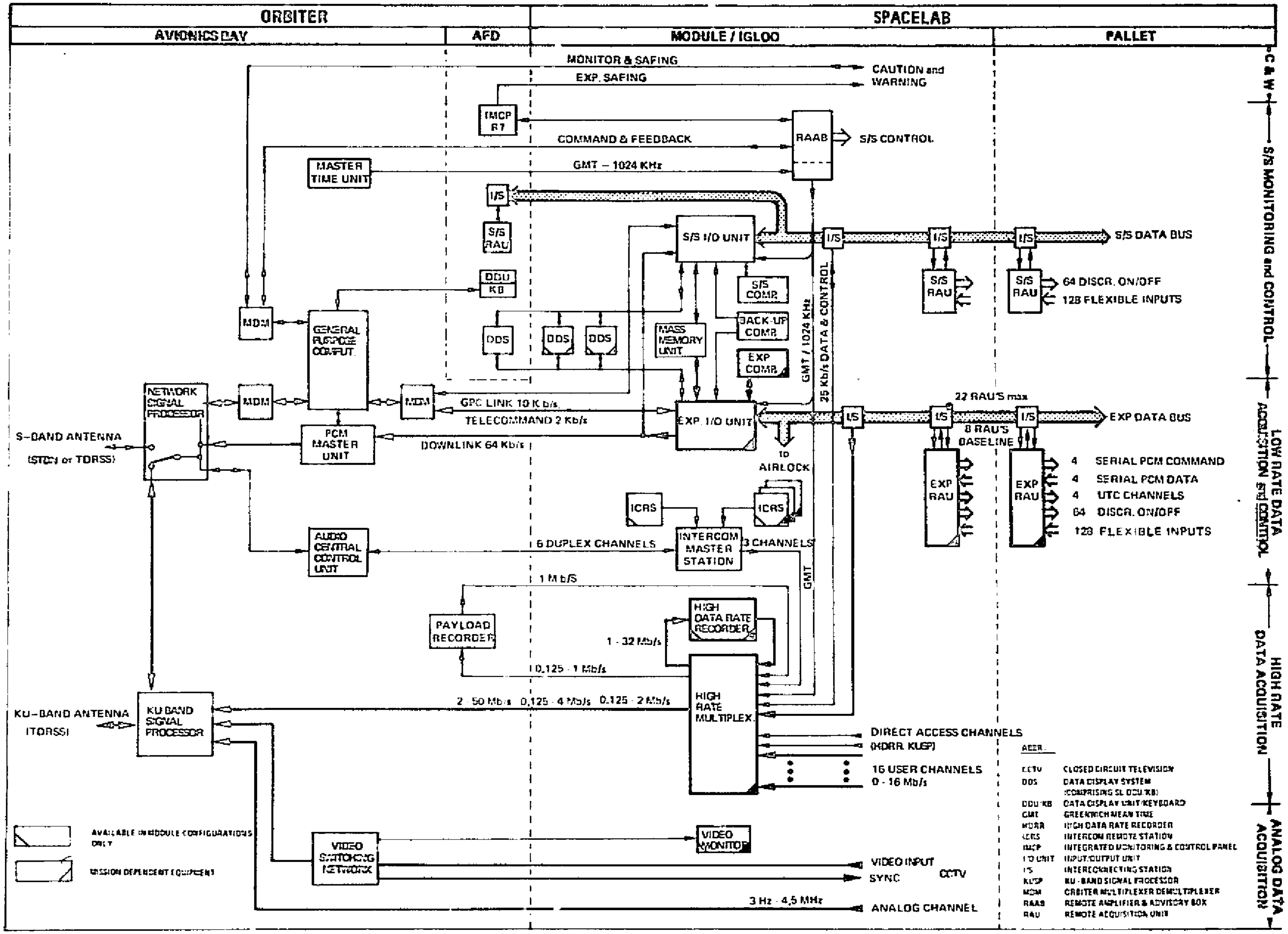


Figure 2-1 CDMS Block Diagram

ORIGINAL PAGE IS OF POOR QUALITY

Data processed by the experiment or S/S computer can be displayed on DDU's, which have vector display capability.

Low-bit-rate scientific and housekeeping data processed by the experiment computer can be transmitted by the Orbiter downlink via the TDRSS.

Medium and high-rate scientific data and experiment and subsystem housekeeping data is acquired by the high rate acquisition part of the CDMS. This part consists of the high rate multiplexer (HRM) which includes a voice digitizer, the high data rate recorder (HDRR), and the Orbiter Payload Recorder (PLR). This system is able to multiplex up to 16 experiment input channels and data from the S/S and experiment computer for direct downlink via the TDRSS or for recording (HDRR or the Orbiter PLR) during non-transmission times of the Orbiter Ku-band system. The recorded data may be interleaved with real-time experiment data for transmission to ground.

The voice digitizer in the HRM converts analog Spacelab audio signals into a digital form to allow voice tagging of experiment data multiplexed by the HRM.

Spacelab provides the necessary electrical interfaces for experiment-provided closed circuit television (CCTV) equipment to form an extension of the Orbiter CCTV. There is space for a TV monitor in the control center rack and an electrical interface for video cameras with EIA standard signal output characteristics (monitor and cameras have to be experiment provided). Spacelab also provides a 4.5 megahertz (MHz) analog channel for use by experiments; e.g., to accomodate non-EIA-standard TV signals. A direct interface to the Orbiter Master Time Unit (MTU) is provided.

CCTV and analog signals are transmitted to the ground through the same analog channel of the Ku-band downlink. TDRSS noncoverage times are not bridged by an analog recorder.

Duplex voice links for onboard or Orbiter ground communication are provided by the Intercom System. Emergency, warning and caution conditions are detected and displayed by the Caution and Warning (C&W) System.

2.1.2 Orbiter Elements. The transmission of data generated by Spacelab or Spacelab payload is performed by the Orbiter avionics (see figure 2-2). There are two different types of Spacelab data treated by the Orbiter avionics in different ways.

A. Housekeeping and Low-Rate Scientific Data. For this data, which is routed through the subsystem and experiment I/O units, the 192 kb/s telemetry channel interleaved with Orbiter data is available. This 192 kb/s data stream is split up into:

- Two voice channels, 32 kb/s each

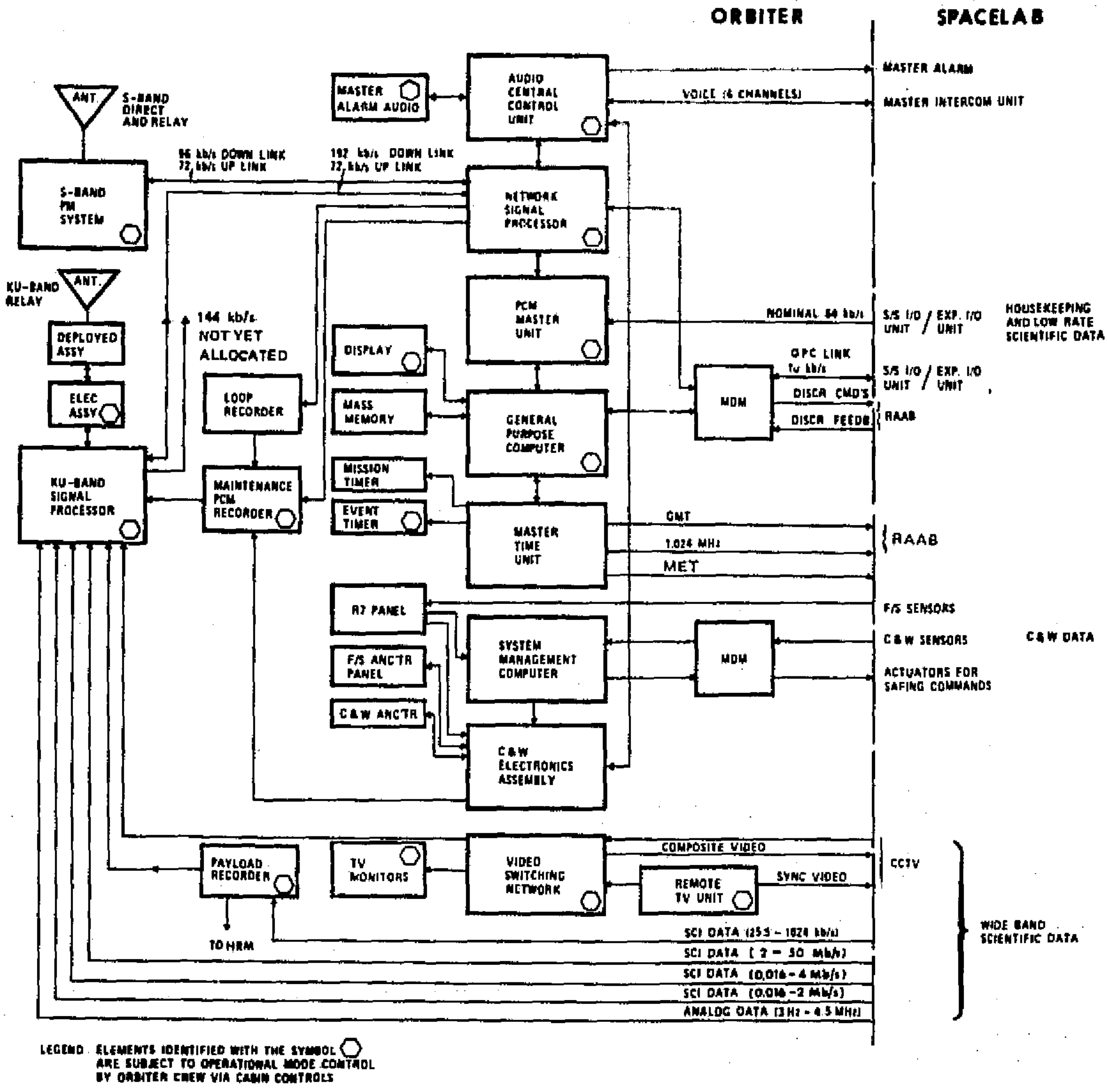


Figure 2-2 Orbiter Avionics Functional Diagram for Payloads

- Orbiter telemetry data, 64 kb/s nominal
- Spacelab data from experiment and subsystem I/O unit outputs, 64 kb/s nominal.

The composition of the data in this 192 kb/s telemetry channel is software-controlled through the PCM Master Unit (PCMMU). The PCMMU acquires the data from different sources [Orbiter General Purpose Computer (GPC), subsystem I/O, experiment I/O] in a demand and response manner. As the Orbiter telemetry data will not read 64 kb/s all the time, it might be possible that experiment and subsystem data can be transmitted at more than 64 kb/s via this telemetry channel. It should be noticed that low-rate scientific data using this link is subject to stringent formatting:

- The PCMMU can request data from the CDMS computers up to 2000 times per second
- Upon one request, up to 10 data words can be transferred
- The requests can address data in a 2K subsection of each CDMS computer.

Controlled by the network signal processor from the PCMMU, the 192 kb/s telemetry channel is transmitted to ground either via the Spaceflight Tracking and Data Network (STDN) to the appropriate STDN ground station, or via TDRSS Ku-band to the TDRSS ground station. From the TDRSS ground station in White Sands, New Mexico, the 192 kb/s telemetry data is sent to the MCC in Houston via ground lines. To bridge TDRSS noncoverage periods, the 192 kb/s telemetry data is buffered on the maintenance/loop recorder in the Orbiter. The TDRSS S-band link provides only a 96 kb/s downlink capability (64 kb/s data + 32 kb/s voice) which has to be shared between Orbiter and Spacelab on a case-by-case base.

B. Wideband Scientific Data. The term "wideband scientific data" covers the digital data from the HRM output, CCTV signals, and the analog data of the 4.5 MHz channel. This wideband scientific data is transmitted to ground only via the Ku-band of the TDRSS. For the digital data, TDRSS noncoverage periods are bridged by the Spacelab HDRR and the Orbiter PLR (see paragraphs 3.1.9.1 and 3.2.1.4). Means to bridge the transmission of CCTV and analog signals are not provided. The Orbiter-controlled mode selection and channel allocation of the Ku-band downlink is performed by the Ku-band signal processor (KUSP). The functional flow chart in figure 2-3 indicates the switching capabilities to combine the various inputs to the KUSP.

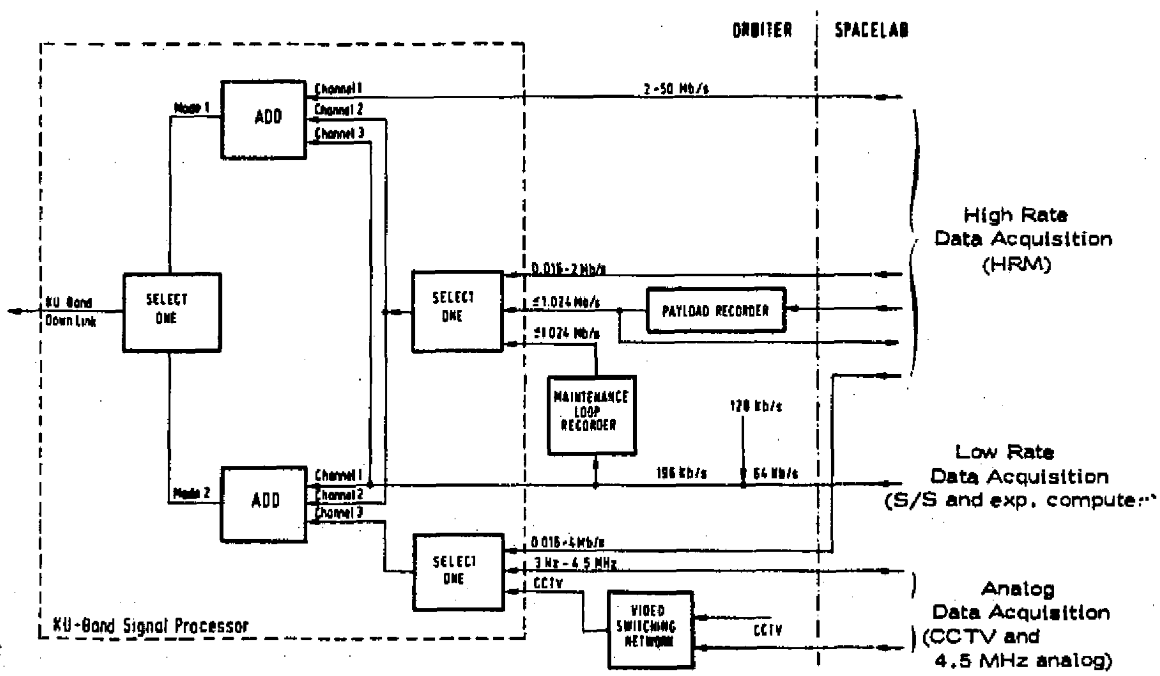


Figure 2-3 Functional Ku-Band Data Processing

The channels available in the two Ku-band modes are summarized in table 2-1. Mode 1 is a phase-modulated transmission line providing one 192 kb/s channel for telemetry data with 64 kb/s out of it dedicated to Spacelab subsystem and experiment computer output data; one 0.016-2 Mb/s channel interfacing with the HRM or the Payload Recorder output; and one 2-50 Mb/s channel interfacing with the HRM. All these channels can be operated in parallel. Mode 2 is a frequency-modulated transmission line providing one 192 kb/s channel (same as in mode 1); one 0.016-2 Mb/s channel (same as in mode 1); and one channel accepting either digital or analog signals. The digital data (0.016-4 Mb/s) is delivered from the HRM output. The analog signals are delivered from the CCTV or from the 3 Hz - 4.5 MHz analog channel directly. The Ku-band link requires a minimum density of bit transitions. To fulfill these bit density requirements, it may be necessary to have some additional overhead in the data stream transmitted via the Ku-band link.

2.1.3 Data Transmission. Figure 2-4 shows the possible transmission links to the ground. Two downlink facilities are available to Spacelab. These are as follows.

A. The TDRSS has two relay satellites and one ground station. The TDRS link to the ground station is performed by Ku-band. The TDRS Orbiter link normally uses the Ku-band, while the S-band is operated only during the first antenna adjustment procedures.

B. The STDN linking the Orbiter directly to various ground stations via S-band will be used only in a contingency mode.

TABLE 2-1
KU-BAND MODE DESCRIPTION (ORBITER-TO-TDRSS)

MODE	CHANNEL 1	CHANNEL 2	CHANNEL 3
1 (PM)	Digital: 192 kb/s (64 kb/s from Spacelab)	Digital: 0.016 - 2 Mb/s	Digital: 2 - 50 Mb/s
2 (FM)	Digital: 192 kb/s (64 kb/s from Spacelab)	Digital: 0.016 - 2 Mb/s	Digital: 0.016 - 4 Mb/s or Analog: CCTV or 4.5 MHz Channel

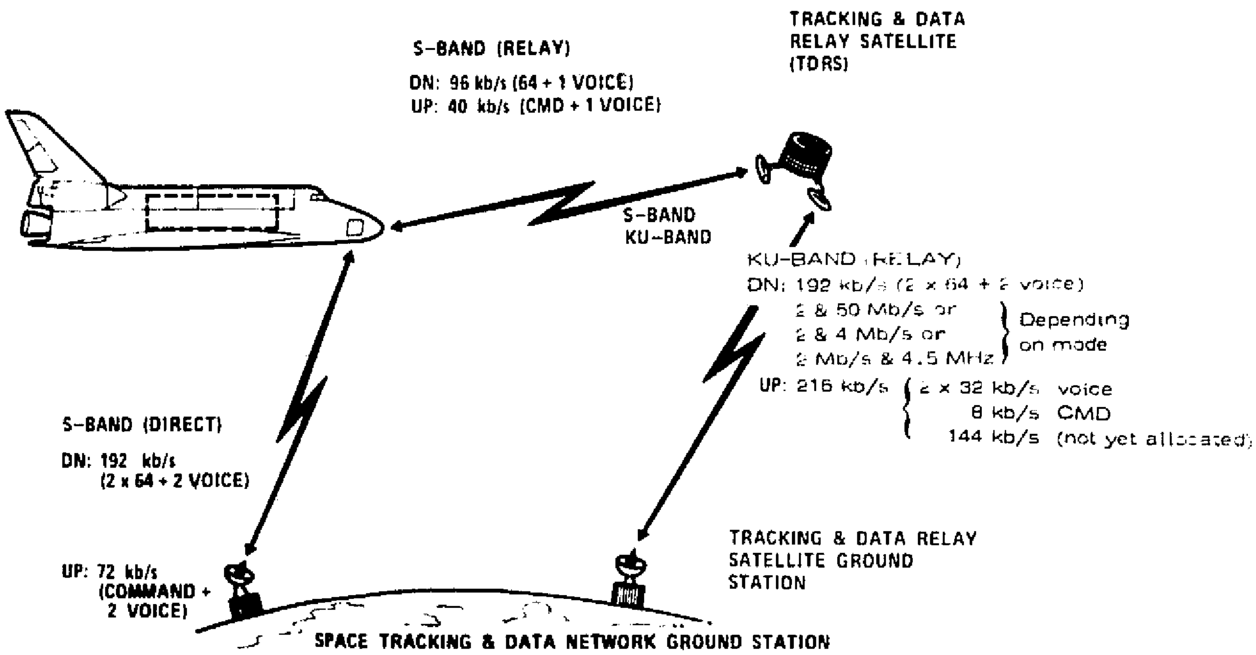


Figure 2-4 Orbital Communication Links

SECTION 3

FUNCTIONAL DESCRIPTION OF SPACELAB ELEMENTS

From a ground data processing point of view, the major elements of the Orbiter vehicle in a SL configuration may be categorized as follows:

A. Command and Data Management System Components

- Computers: subsystem, experiment, and backup
- Computer I/O units: subsystem and experiment
- Data Display System (DDS): two in module and one in aft flight deck
- Mass memory unit (MMU)
- High-rate multiplexer (HRM)
- Remote acquisition unit (RAU)
- Remote amplifier and advisory box (RAAB)
- Spacelab recorders.

B. Orbiter/Spacelab Interfaces

- Telemetry
- Command
- Caution & warning (C&W)
- Voice
- Analog data
- Master timing unit (MTU)

3.1 COMMAND AND DATA MANAGEMENT SYSTEM (CDMS) COMPONENTS

3.1.1 Computers. There are three identically configured MITRA 125/MS GPC's aboard Spacelab. One is utilized as the subsystem computer; the S/S computer provides monitoring, command, and control of non-experiment dedicated SL subsystems.

In general, the subsystem portion of the CDMS (i.e., S/S computer, S/S I/O, S/S RAU's and associated data bus) will not have an operational interface with experiments. The main CDMS subsystem services are to:

- Accept commands from Orbiter GPC and SL keyboard for activation, management, and deactivation of CDMS components
- Acquire subsystem data for transmission to Orbiter via PCMMU and MDM links for management of CDMS
- Provide fault detection and annunciation for SL parameters as a backup to Orbiter C&W function
- Perform internal CDMS fault detection and protection
- Display subsystem status.

There are, however, several functions performed by the S/S computer which do relate to experiment operation. These are as follows.

A. HRM and HRDR Control. Commands to (1) specify the inputs, bit rate, and output bit rate the HRM will use, (2) determine routing from the HRM to HRDR, PLR or KUSP, and (3) sequence HRDR record and playback are controlled from the S/S computer. Therefore, for experiment data to be transmitted to the POCC, the HRM and HRDR must first be properly configured by the S/S computer. This reconfiguration can be accomplished via POCC commands or onboard keyboard input.

B. IPS Control. For experiments which are attached to the Instrument Pointing Subsystem (IPS) to function properly, the IPS must be pointed to and/or tracking the desired target. The S/S computer is responsible for generating and issuing pointing and mode commands to the IPS and for assisting in control about the target. Therefore, for experiments located on the IPS to operate, the S/S computer must first position the IPS in the proper direction and command the appropriate control mode to maintain tracking.

C. Experiment C&W. The S/S computer will provide a C&W capability for critical experiment hardware. This is a backup to the Orbiter C&W capability.

D. Subsystem Corollary Data. The S/S computer collects subsystem corollary data and output to HRM via S/S data bus. Data will be ≈ 25.6 kb/s.

Table 3-1 describes the basic characteristics of the MITRA 125/MS GPC.

The second computer is dedicated to experiment-unique functions. This hardware, along with NASA-provided Experiment Computer Operating System (ECOS) software provides experiments with the general capabilities required to:

- Operate the various experiment computer interfaces during flight
- Activiate/deactivate individual experiments
- Control and monitor experiment hardware during experiment operation
- Process and display data from operational experiments
- Perform experiment caution/warning functions
- Interface with the Orbiter GPC's for ground command interface purposes
- Perform computational and other general data processing services required by experimenters on a case-by-case basis
- Generate data acquisition and downlink via the high rate multiplexer and PCMMU interfaces.

The third computer serves as a backup for the other two. Normally, the backup computer is loaded with the S/S computer software; however the experiment computer may be loaded via crew or ground command.

TABLE 3-1
BASIC MITRA 125/MS COMPUTER CHARACTERISTICS

Formats

Operands: 8, 16, 32 and 24 + 8 (floating points) bits

Instructions: 16 bits

Control Unit

Micro-programmed control unit

Cycle time 300 ns

Micro-interrupt capability

Micro-instructions 4 K words of 16 or 20 bits

Instruction Set

- Number of instructions 128
- Format 16 bits
  Immediate 8 bits
- Addressing capability
  Direct 256 Bytes
  Indirect memory double word
  Relative 512 bytes
  Based 256 bytes
  Indexed 64 K bytes
- Type
  Call and store
  Logic and comparison operations
  Shift operations
  Fixed-to-floating and floating-to-fixed conversions
  Conditional and unconditional jumps

Addressing Modes

Immediate, direct, indirect, relative to a base, indexed, relative to a program counter, half word, word, character, double word

- Addressing capability
  Byte, word, double word

Number of Adressable Registers

4 Specialized registers

62 Dedicated registers

7 Base registers

Computing Speed

Fixed Point 16 Bits

Add/Sub	Direct	2	µs
	Indirect	3	µs
Mul/Div	Direct	4	µs
	Indirect	5	µs

Fixed Point 32 Bits

Add/Sub	Direct	5,5	µs
	Indirect	6,5	µs
Mul/Div	Direct	8,3	µs
	Indirect	9,3	µs

Floating Point 32 Bits (24 + 8)

Add/Sub	Direct	5	µs
	Indirect	6	µs
Mul/Div	Direct	6	µs
	Indirect	7	µs

Gibson Mix $3.5 \cdot 10^5$ Operations/Second

Input/Output

- Interrupts
  - Number of external: 8 Levels
  - Number of internal: 5 Levels
  - Number of software: Program dependent
  - Interrupt control: Microprogram + Software
  - Priority scheduler: Software
- Data transfer mode
  - Program controlled
    data rate: 60 µs/word
    no of addressable peripherals: 65 k
  - Direct memory access
    data rate: 400 to 800 K word/sec
    control: direct
- Word length: 16 bits plus 1 parity + 1 protection
- Discretes: 8 inputs and 8 outputs
- Real time work: 1 µs to 2^{32} ms

Memory

- Type: 18 mil ferrite cores 2 1/2 D configuration
- Capacity: 64 K 16-bit words (plus 1 parity bit and 1 protection bit)
- Modularity: 16 K words
- Cycle time: 900 ns
- Addressing, Quantum: Byte, word
- Access time: 420 ns
- Ports: 2

3.1.2 Computer Input/Output Units. All communications between the computers and the rest of the CDMS are handled by the I/O units which control the transfer of external data into the computer memory and the transfer of data from the memory to all peripherals. A simplified block diagram of the I/O unit is shown in figure 3-1. The I/O unit has six interfaces with the rest of the CDMS and the Orbiter. These are:

A. CDMS

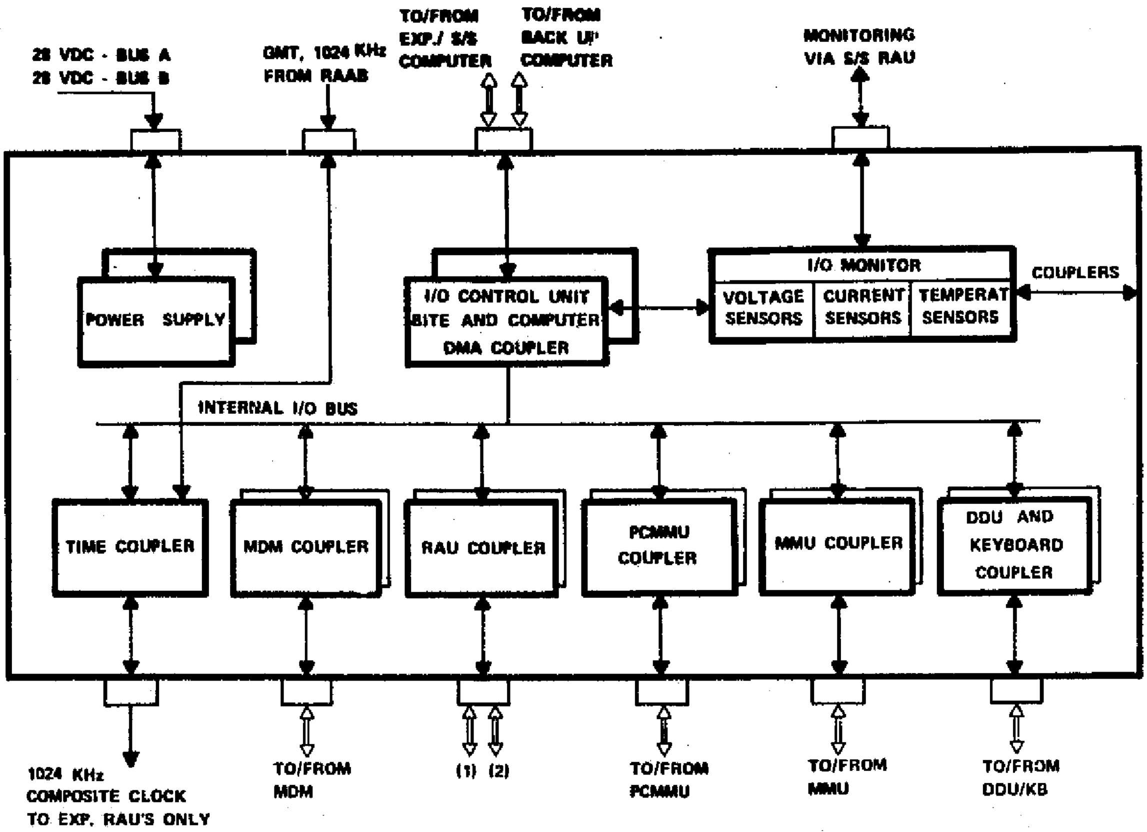
- Remote acquisition units and high-rate multiplexer
- Data display units and keyboards
- Mass memorv.

B. Orbiter

- MDM
- PCMMU
- Master time unit (via RAAB).

Each interface is controlled by a "coupler," which is attached to the non-redundant internal parallel bus of the I/O unit. Each coupler, except the "time coupler," is dual redundant and communicates with the rest of the CDMS or Orbiter as appropriate via serial data buses. Only one coupler of a redundant pair is powered at any time. The switchover from one coupler to a redundant one will be performed by the following procedure:

- Switch off computer power
- Switch over to the redundant coupler
- Switch on computer power
- Initiate restart procedure (present baseline requires sequence of commands via keyboard. An "Auto-restart" sequence will be introduced thru ECF MA - 50 556 - xx. For more details see RP - MA - 0019).



(1) TO/FROM EXP./ S/S RAU'S CONNECTED TO MAIN BRANCH OF EXP, S/S DATA BUS

(2) TO/FROM EXP. RAU'S CONNECTED TO AIRLOCK BRANCH OF EXP. DATA BUS OR TO/FROM S/S RAU'S CONNECTED TO AFD BRANCH OF S/S DATA BUS

NOTE: THIS DIAGRAM DOES NOT REFLECT MONITORING AND CONTROL OF THE I/O UNIT VIA MDM'S

Figure 3-1 Simplified Block Diagram of the I/O Unit

The interface between the I/O unit and the prime (and backup) computer is performed by the redundant Direct Memory Access (DMA) coupler. This coupler receives and generates control discretes from and to the computer memory interface and receives and transmits address and data over a 16-bit parallel memory bus. Only one DMA coupler is powered at any time, corresponding to the prime or backup computer, which is powered.

Each peripheral coupler incorporates a microprocessor to supervise the transfer of data to or from the computer memory. It is capable of performing simple tests to ensure the validity of the data, such as parity checks, word count, and time out.

A coupler in the I/O unit is initialized by the transfer of two words (Status Table) from the computer memory. It then uses these words to point to an instruction list in the computer memory consisting of a number of word triplets (Command Table), each one defining one transaction for that coupler. It executes these to transfer data into, or out of, a data table to perform its interface function. Once initiated, this activity can proceed in parallel with the Central Processor Unit (CPU) use of the memory, although only one access to the memory can be accommodated at any instant. Because of the serial data transfer through the couplers and parallel data transfer with the memory, up to five couplers can effectively operate simultaneously.

The I/O unit has priority over the CPU memory access. If more than one coupler is queued for memory access, memory data is transferred in multiple word blocks which is more efficient (in time) than single word transfer.

Coupler access to the computer memory is controlled on a priority basis by the I/O control unit. The PCMMU has been assigned the highest priority because of response time constraints imposed by the PCMMU.

The second highest priority is assigned to the RAU coupler followed by the MDM coupler (3), MMU coupler (4) and DDU/keyboard coupler (5).

3.1.3 Data Display System. The operator/computer interface is performed via the data display system comprising the data display unit (DDU) and an associated keyboard (KB). SL provides one DDU/KB in the module (control center rack) and one DDU/KB in the Orbiter aft flight deck (AFD). The experimenter may operate a third SL provided DDU/KB in an experiment rack. SL provides all necessary signal interfaces routed to connector bracket to operate a DDU/KB. The experimenter will be responsible for the power harness and the special harness between connector bracket and the DDU/KB.

All DDU/KB's are connected both to the subsystem I/O unit and the experiment I/O unit by means of redundant display buses similar to the data buses.

Each DDU can display information from both computers simultaneously, and the display format is chosen and determined by software. Each KB can communicate via the DDU and the display buses with the S/S and experiment computer by means of a manual switch. Each KB also has the ability to call either subsystem or experiment information for display on any of the three DDU's by means of three switches (CRT 1, 2, 3).

The DDU has a tricolor (green, yellow, red) penetration type cathode ray tube with a 12-inch diagonal screen. The DDU can display 128 different symbols with a total number of 999 characters on 21 lines of 47 characters and has a vector display capability. A power saving mode of operation is implemented in which the DDU is on standby, waiting for information from the computers. After receipt and storage of the information, the DDU is in full operation within 2 - 5 sconds. A manually adjustable timer (30 sec. to 5 min.) switches the DDU back to the standby mode, awaiting new information. This feature can be inhibited by the operator.

The major hardware characteristics of the DDU are summarized below.

- Buffer memory size: 1024 words of 16 bits
- Available characters: 128
- Size of alphanumeric characters: 4.8 × 3.2 mm or 4.8 × 1.6 mm
- Space between characters: 1.5 mm
- Space between lines: 2.5 mm
- Position matrix on viewing area: 820 × 620
- Refresh rate: 30 Hz to 60 Hz.

3.1.4 Mass Memory Unit. The mass memory unit is a tape recorder for storage of all basic and flight application software for the S/S and the experiment computers, thus enabling the CDMS to reload the computer memories from the MMU. Besides this, the MMU will be able to accomodate experiment data for comparison purposes or usage within experimenter-provided programs. The MMU will also provide a limited capability to roll in S/S or experiment programs exceeding the computer core memory size. About 50 percent of the MMU storage capability is available for experiments. The software for onboard writing into the MMU from the experiment is TBD.

A. Total storage capability: 1.34×10^8 bits.

B. Organization as follows:

- Files: 8
- Subfiles: 64
- Blocks: 2048 of 512 words
- Transfer rate: 1 Mb/s
- Access time: 2.8 s average within any file
- Start time: 0.7 s to the first data block
- Bit error rate: less than 1 in 10^8 bits.

3.1.5 High-Rate Multiplexer

3.1.5.1 General. Since the HRM represents the core of the high data rate assembly, the tasks of the HRM are not constrained to the actual data multiplexing. The HRM also controls the data routing within the onboard part of the high data rate assembly, it performs the voice digitizing and GMT decoding, and it provides the electrical interface circuits to the onboard interlinking equipment. The main characteristics of the HRM are listed in table 3-2.

3.1.5.2 Multiplexing Concept. The HRM collects serial data from different sources, performs a time division multiplexing based on 16-bit time intervals and, finally, delivers an output of one serial data stream containing all the input data.

The main characteristic of the concept employed is the capability to accept serial data that are completely asynchronous with respect to the HRM internal clock. As shown in figure 3-2, the decoupling of the input clock from the HRM internal clock is performed by means of 4 × 16 bit input buffers.

TABLE 3-2
HIGH-RATE MULTIPLEXER CHARACTERISTICS

Outputs to KUSP	
bit rate	48 Mb/s, 32 Mb/s to 125 kb/s in binary steps
code for 50 Mb/s KUSP input	NRZ – S + clock
code for 2 Mb/s and 4 Mb/s inputs	NRZ – S without clock
Output to HDRR	
bit rate	32 Mb/s to 1 Mb/s in binary steps
code	NRZ – L + clock
Output to Payload Recorder	
bit rate	1 Mb/s to 125 kb/s
code	Manchester biphase L
Input from HDRR	
bit rate	32 Mb/s to 2 Mb/s in binary steps plus 12 Mb/s and 24 Mb/s
code	NRZ – L + clock
Input from Payload Recorder	
bit rate	1 Mb/s
code	Manchester biphase L
Experiment Input Channels	
number	16
nominal bit rate	
at 48 Mb/s HRM output rate	16 Mb/s to 62.5 kb/s (1)
at 32 Mb/s HRM output rate	16 Mb/s to 41.7 kb/s
nominal bit rate at HRM output rates lower than 32 Mb/s	above rates divided by ratio 32 Mb/s to actual output rate
Direct Access Channels	
number	2
maximum bit rate	50 Mb/s
CDMS Computer Channels	
number	2 (1 for S/S, 1 for exp. computer)
maximum data rate	25.6 kb/s (2)
GMT Channel	
resolution for HRM output rates ≥ 1 Mb/s	10 ms
resolution for HRM output rates ≤ 1 Mb/s	4 frame lengths (3)
Voice Channel	
number of analog inputs	3
total bit rate	128 kb/s

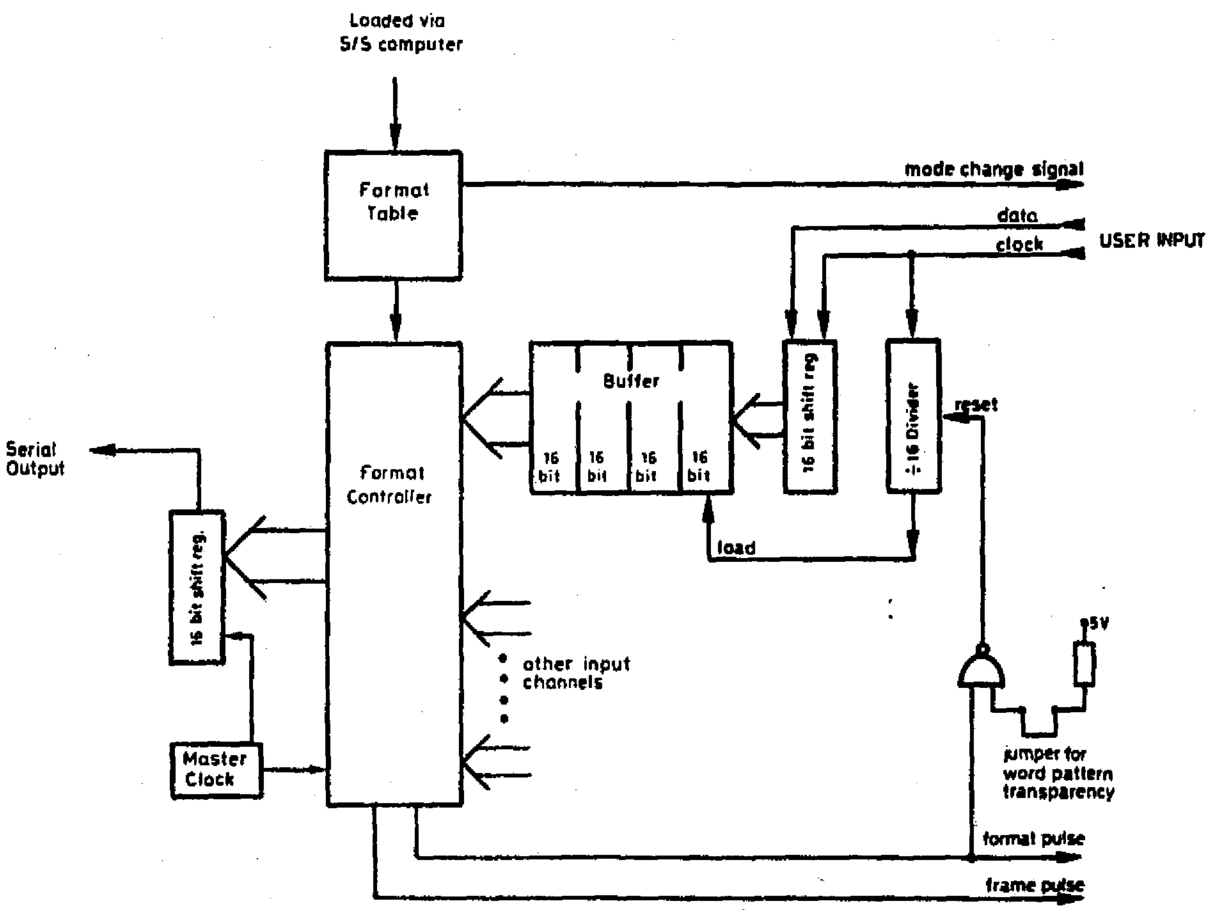


Figure 3-2 Multiplexing Concept

The user clocks in his data into a 16-bit shift register; then -- after 16 bits -- the content will be loaded into the 4 × 16-bit buffer.

In a sequence determined by the format loaded, the format controller fetches one 16-bit word out of the input buffer and transfers it to the output register, where it will be serialized. In the case of an empty input buffer, a fill word is introduced, which can be identified as such by means of the fill identification as a part of the frame overhead. During demultiplexing on ground, the fill words are automatically suppressed.

By this method, only two constraints are imposed on input data rates:

- The input bit rate averaged over any sequence of 64 bits shall not be higher than the nominal data rate allocated. If the input bit rate is higher, the input buffer will overflow. Overflows will be announced to the S/S computer
- The peak bit rate shall not be higher than 16 Mb/s. This constraint is due to the hardware limitation of the HRM input circuits.

The user delivering serial data to the HRM will, on ground, recover his data from the HRDM completely unchanged. This means that the user himself has to take care of the formatting and structuring of his serial data. To facilitate this task, each HRM experiment channel can operate in two different modes as follows.

A. Normal Mode. In this mode, the word structure in the HRM output frames are not at all correlated with any structure of the input data. The serial input data is arbitrarily chopped into 16-bit words for parallel processing inside the HRM. Consequently, the user has to insert some kind of sync pattern into his serial input bit stream, in order to be able to extract on ground his scientific data out of the serial bit stream of his output channel.

B. Word Pattern Transparency Mode.* In this mode, the input data can be structured in words that, after multiplexing, can be identified as words in the HRM output frames in those positions determined by the chosen format. Synchronously with the frame or format pulse, which indicates the beginning of a new frame or format respectively, experiment data can be delivered to the HRM in bursts of 16-bit words. Because the clock counter is reset at the beginning of each format, these words are identical to the internal words the HRM handles in parallel.

   The HRDM in this mode delivers the data words without bit rate smoothing at the nominal bit rate allocated to the particular experiment channel.

   The mode (normal or word pattern transparency) of each input channel is determined by an external HRM connector. This connector is programmed by hardwired jumpers on a mission-to-mission basis.

*This mode is not supported by the JSC POCC.

3.1.6 <u>Pre-HRM Switching Network</u>. Deleted.

3.1.7 Remote Acquisition Unit

3.1.7.1 Functional Concept. The RAU's are the principal interfaces for the bidirectional link between experiments and the CDMS for acquisition of low-bit-rate digital data, analog data and distribution of commands. The data exchange between RAU's and the I/O unit is performed via simplex serial buses with 1 Mb/s clock rate. The data is encoded in a self-clocking bi-phase code (Manchester II). Each experiment RAU incorporates the following user interfaces:

A. Inputs:

- 128 flexible differential inputs for analog or discrete signals
- 4 serial PCM data channels with associated clocks, code NRZ-L.

B. Outputs:

- 64 ON/OFF command channels
- 4 serial PCM command channels with associated clocks, code NRZ-L
- 4 user time clock channels (1024 kHz)
- 4 user time clock update channels, 4 pulse cycles per second.

A block diagram of the RAU is given in figure 3-3. It should be noted that the measuring points shown are for bench testing only.

The RAU data acquisition is based on a software controlled concept. The software for subsystem data acquisition and control is provided by SL. The software for experiment data acquisition and control has to be provided by the experimenter in accordance with his requirements. Applicable portions of the SL software can be used by the experimenter.

The RAU's will be scanned periodically with basic periods of 10 ms, 100 ms, or 1 second. Each scan cycle will be initiated and controlled by the GML which is part of the SL computer software. The experimenters may design their own software to generate additional measurement cycles using the operating system task scheduler. This scheduler will accept priority levels and queue up experiment software requests for data and command transmission.

3.1.7.2 Physical Concept. Thirty-two different addresses are foreseen for the RAU's on a bus. The address for a particular RAU is determined by a patch connector. For electrical reasons the buses (S/S and experiment bus) are split into two branches, causing a split of the 32 RAU addresses on each bus.

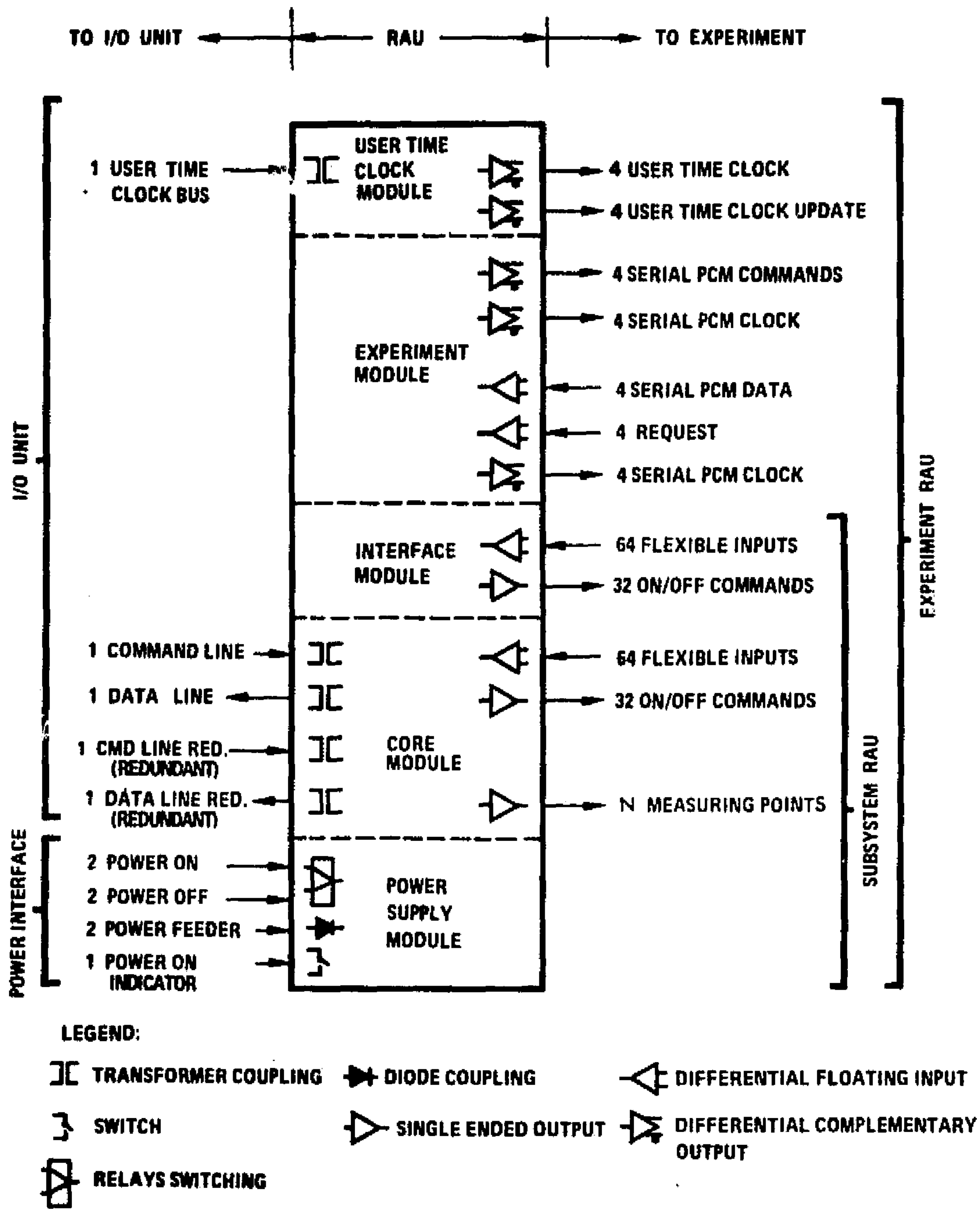


Figure 3-3 RAU Block Diagram

The split for the S/S bus is:

- AFD branch, addresses 0 to 7 (including IPS subsystem RAU's)
- Main branch, addresses 8 to 31.

The split for the experiment bus is:

- Airlock branch, addresses 0 to 7 (including IPS experiment RAU's)
- Main branch, addresses 8 to 31.

The electrical characteristics of the buses allow the accommodation of up to 22 RAU's per branch.

Eight experiment RAU's is the total number of units delivered by the SL program.

Experiment RAU's can be connected to the experiment data bus at a number of interconnecting stations (IS's) in the module and on each pallet. There are two interconnecting stations in the core segment, three in the experiment segment, and two on each pallet segment. Each station accommodates two RAU's.

The SL baseline provides standard locations for RAU's in the lower part of the experiment racks. However, the concept allows the user to integrate RAU's together with his experiment equipment, if he uses his own racks and/or experiment equipment mounted directly to the center aisle or to the pallet. In every case the user has to ensure that:

- The cable length, between RAU and interconnecting station is below 5 meters
- The applicable interface specifications of the RAU are met in accordance with EQ-MA-0003.

There are two different types of RAU. The smaller type is the subsystem RAU consisting of the power supply module, core module, and the interface module (see figure 3-3). The larger type is the experiment RAU consisting of the subsystem RAU modules plus the experiment module (which provides serial PCM input and outputs) and the UTC module. The functions of the RAU are described in appendix C.

3.1.8 Remote Amplifier and Advisory Box. The RAAB is the interface between the Orbiter MTU and Spacelab elements. The function of time signal distribution is of interest to the POCC system designers.

3.1.8.1 Time Distribution. The MTU in the Orbiter generates and distributes a central "onboard time." The long term drift of the MTU will be 1×10^{-9}/day giving an accuracy better than 3 ms during a 7-day mission. The deviation of the onboard time from ground time will be controlled and logged on ground with an accuracy better than 1 ms. If the deviation is more than ±10 ms, the Orbiter MTU will be readjusted externally. From the Orbiter MTU, two different time signals are derived in Spacelab and are available for experiment time tagging.

A. The GMT serving as "macroscopic" time information. This GMT has a time resolution of 10 ms. It can be distributed to experiments via the RAU serial PCM command channels. The GMT is also inserted into the HRM data frames, thus providing automatically a macroscopic time tagging of experiment data acquired by the HRM.

B. The 1024 kHz User Time Clock (UTC) serving as "microscopic" time information. This UTC has a time resolution of 1 μs. It is distributed hardwired to the experiments via the RAU UTC channels.

The Spacelab time distribution system is designed to provide a relative accuracy of better than 10 μs. A functional diagram of the time distribution system is shown in figure 3-4. The MTU 1024 kHz signals are routed through the RAAB to the time coupler in the experiment I/O Unit. The time coupler generates the "UTC update" which is a 250-ms signal derived from the 1024 kHz clock. This is done by:

- Incrementing a 18-bit counter which is reset every 250 × 1024 pulses
- Forming a composite clock by modulating the 1024 kHz clock every 250 ms, 8 pulses before the counter reset.

At the RAU level, the composite clock signal is demodulated in order to provide the two signals UTC (1024 kHz) and UTC update (four pulses long, sync every 250 ms). The end of the UTC update sync pattern is correlated to the 18-bit counter reset. The detailed phase relationship can be seen from figure 3-5.

The time coupler also performs the correlation between the UTC update and the GMT. Every 250 ms, synchronously with the GMT, the 16 most significant bits (MSB's) are loaded into the correlation register. This 16-bit word Θ represents the correlation between GMT and UTC update with an uncertainty of 4 μs because the last two bits of the 18-bit counter have been dropped.

Both the decoded GMT and Θ are transferred periodically via the time coupler buffer into the experiment computer.

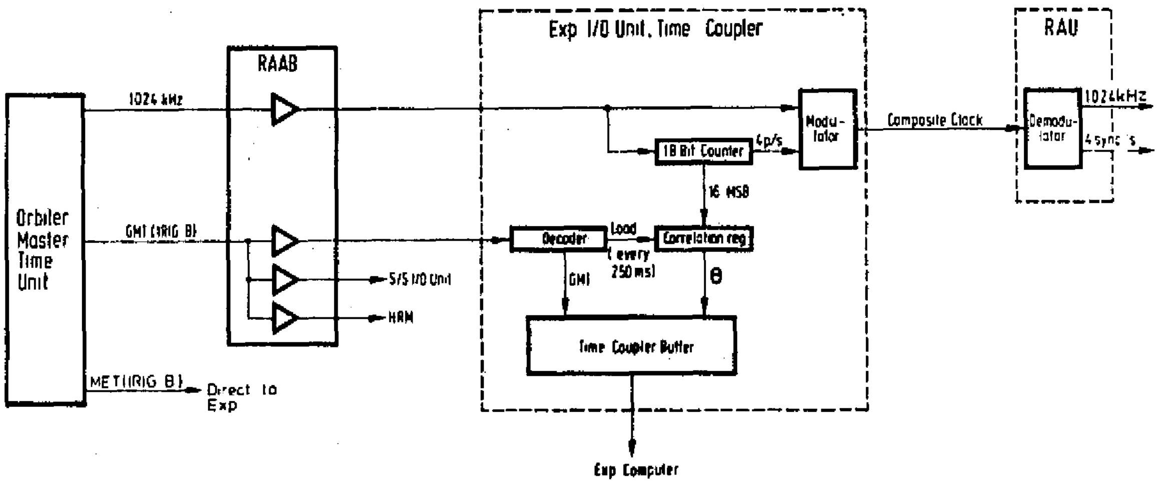


Figure 3-4 Time Distribution System Functional Diagram

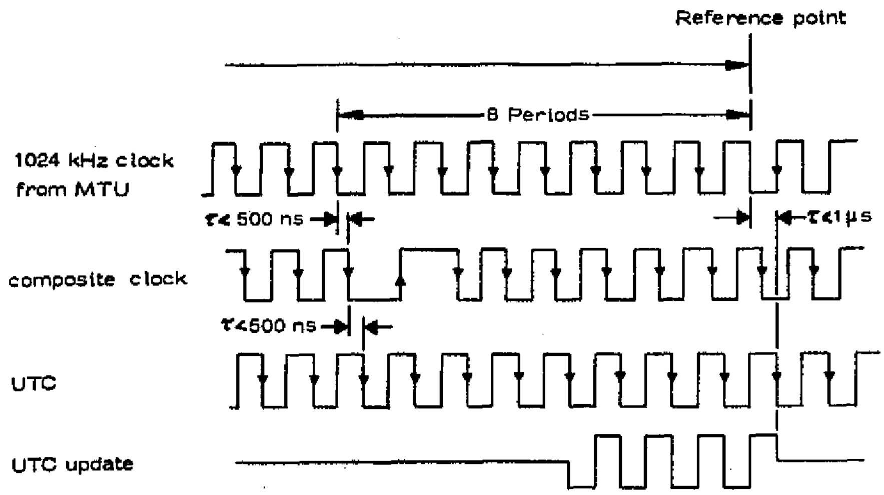


Figure 3-5 Phase Relation Between MTU Clock Signal and UTC Clock Signals

Θ is used to time-tag experiment data in the experiment computer with an accuracy of 10 μs. For this time tagging method, it is assumed that the experiment contains a time counter (counting the 1024 kHz UTC pulses) which is reset by the UTC update signals every 250 ms. For each experiment event, the event data has to be acquired together with the related contents of the experiment time counter. The experiment computer then, by means of Θ, calculates back the experiment time counter contents to the onboard time. However, in order to relate the event unambiguously to the onboard time, the data acquisition and computation has to be performed less than 250 ms after the event.

Θ also allows (together with UTC, UTC update, and GMT) time tagging to be performed autonomously in the experiment. In this case Θ, or better an averaged Θ compensating GMT signal jitter, can be sent to the experiment via a serial PCM command channel for the correlation between UTC and GMT.

In addition to the time information distributed to the experiments through the CDMS, a direct interface to the Orbiter MTU is available for experiments. The time delivered is the Mission Elapsed Time (MET). The interface is at CB 5 in module configurations and at CB 57 in pallet only configurations.

As shown in figure 3-6, the time information is delivered in a modified IRIG-B format, i.e., a pulse width modulated pulse train (100 pulses per second) contains the binary coded decimal (BDC) information in seconds, minutes, hours, and days. The main characteristics of this format are:

- Frame: 1 second length
- Subframe: Separated by position identifiers P0 through P9. The first five frames contain seconds, minutes, hours and days, BCD coded. The remaining frames are empty
- Position identifier: Pulse of 8 ms duration
- Binary 1 pulse: Pulse of 5 ms duration
- Binary 0 pulse: Pulse of 2 ms duration.

The IRIG B format is modified so that the "straight binary seconds", which begin at Index Count 80, will not be generated. The IRIG format will be modulated with a 100 p/s output rate and a resolution of 10 ms. The IRIG B format code will be transmitted with the least significant bit transmitted first.

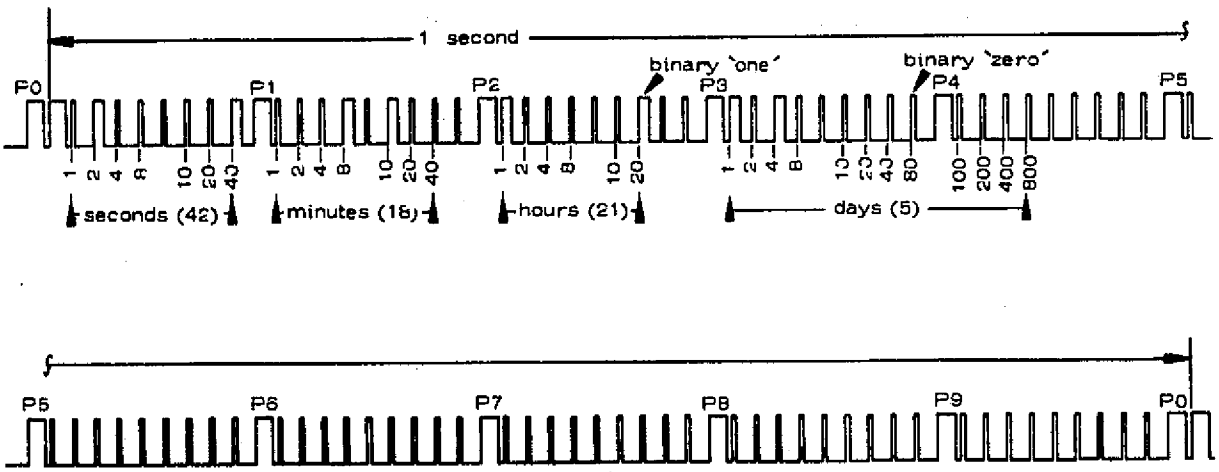


Figure 3-6 MET Output Format

The RAAB contains additional circuitry which performs a monitoring and command feedback function for critical Spacelab subsystems. Examples are the Environmental Control System water line heater, fire sensors, and Avionics System fans. The RAAB is interfaced to the Spacelab AFD R-7 control panel and to subsystem RAU's which present data from the RAAB to the S/S computer.

As a general note, the RAAB appears to be a box into which a variety of electronic functions unavailable elsewhere in the Spacelab have been lumped to minimize interface impact between Orbiter and Spacelab. A list of these functions will be provided as an update sheet to this document.

3.1.9 High Data Rate Recorder (HDRR). See table 3-3 for recorder characteristics.

A. Principle Function. The principle function of the HDRR is to provide for intermediate recording of experiment data during interrupted Orbiter-to-ground TDRSS transmission times. The HDRR may also be used by the experimenter to record his experiment or housekeeping data for onboard storage.

B. System Interfaces. The HDRR and the HRM form an integrated system with both being controlled by the CDMS subsystem computer in a coordinated manner. The experiment interfaces with the HDRR are via the HRM only, but two direct experiment channels are provided which bypass the multiplexer unit in the HRM. The HDRR will be externally synchronized by the HRM clock during record and playback.

C. Functional Usage. The HDRR will be used as a buffer during TDRSS non-coverage times or Ku-band modes with bit rates below the HRM output bit rate. During playback (always in reverse direction), the recorded data can be interleaved into the real-time data stream through its dedicated input channel of the HRM, or dumped directly to the KUSP through a direct dump channel. Data recording for onboard storage (experiment or housekeeping data) without transmission to the ground is possible only during periods when all required data for transmission has been recorded, leaving a gap of otherwise idle time, and making the tape change capability of the HDRR useful for the experimenter.

D. Control. Operational control of the HDRR will be effected via discrete commands from a subsystem RAU. Sufficient local controls are provided on the HDRR transport unit to allow tape change and to inhibit normal control. In addition to monitoring commands status and recorder housekeeping signals, the subsystem RAU also receives a parallel 8-bit word representing tape used, to be interpreted by software to represent tape used for display on the DDU.

TABLE 3-3
HIGH DATA RATE RECORDER CHARACTERISTICS

Record Technique	longitudinal, 28 tracks
Data Tracks	24
Data Storage	3.6×10^{10} bits
Bit Density/Track	21 kb/inch
Data Rate Record	1,2,4,8,16,32 Mb/s or 1 thru 32 Mb/s via direct access
Data Rate Playback	2, 4, 8, 16, 24, 32 Mb/s
Total Record Time	20 min at 32 Mb/s
Data Type	Serial in, Serial out, NRZ-L + clock
Bit Error Rate	1×10^{-6}
Playback Direction	reverse to record direction
Start Time	5 s
Stop Time	2.5 s
Tape Handling	tape cartridge, automatic threading
Tape Loading Time	0.4 min.
Wind/Rewind Time	7.5 min each
Tape Width/Reel Diameter	1" / 14"
Tape Reel with Tape and Cartridge	4.8 kg

3.2 ORBITER/SPACELAB/INTERFACES

The primary communications interfaces between Spacelab and Orbiter are as follows:

A. Telemetry

- Spacelab computers to PCMMU
- Spacelab computers to Orbiter GPC via PCMMU random access memory (RAM)
- HRM to KUSP
- HRM to Orbiter Payload Recorder (PLR).
- PLR

B. Command

- Orbiter GPC to Spacelab computers via MDM
- Orbiter DDS to GPC to Spacelab computers
- R-7 control panel to Spacelab subsystems.

C. Caution & Warning (C&W) Interfaces

D. Voice Interface (Intercom System)

E. Analog Data Interfaces

- CCTV
- 4.5 MHz analog channel.

F. MTU Interface

3.2.1 Telemetry Interfaces. Telemetry data is transferred from Spacelab to the Orbiter for both onboard monitoring and subsequent downlink to the ground. During certain phases of the flight, Spacelab experiments may also require use of the PLR located in the Orbiter for the recording of digital telemetry data during nonacquisition periods. Responses to ground-originated commands will be contained in one or more of the telemetry streams interfaced with the ground through Orbiter subsystems.

3.2.1.1 Spacelab to PCMMU Interface. Both the Spacelab experiment computer (EC) and the subsystem computer (SSC) are interfaced to the Orbiter via the PCMMU. The PCMMU issues a series of fetch commands to both computers every second. These commands are received by the respective computer IOU's and the requested data is read from the computer memory and returned to the PCMMU; this operation is performed as a direct memory access (DMA) transfer and no interrupt processing is required of the computers.

The sequence of the PCMMU fetch commands and the computer memory addresses which they reference are defined before the mission and cannot be modified in flight.

The data returned to the PCMMU is stored in a RAM and is made available to both the Orbiter GPC's and the OD telemetry formatter. The amount of data included in the OD is nominally 64 kb/s.

More details of this operation are contained in section 4 and appendix E of this report.

3.2.1.2 HRM to KUSP. Data from the HRM is routed to the KUSP and made available for downlink to the ground via TDRSS. This data is the composite HRM output of up to 50 Mb/s; data from 16 experiment channels, two computer I/O channels, two recorder playback channels, two direct access channels (DACH's) bypassing the multiplexer, one GMT channel, and three voice channels may be included. This interface is the *only* dedicated path to the ground for high-rate science data. Details of KUSP operation are contained in paragraph 2.1.2,B of this report.

3.2.1.3 HRM to Orbiter PLR. The composite HRM output or either of the two direct access experiment channels may be routed to the Orbiter-provided PLR; the maximum rate which can be recorded by the PLR is 1.024 Mb/s. Due to its low capacity for high rate data, only minimal use of the Orbiter PLR by Spacelab is anticipated. The dump output of the PLR may be routed directly to the ground via the KUSP, or routed back to the HRM for inclusion in the composite multiplexed output format to the KUSP.

3.2.1.4 Payload Recorder

A. Principle Function. The PLR is a multitrack coaxial reel-to-reel magnetic tape transport and associated electronics with the principle function of storing and reproducing both digital and analog experiment data. The PLR primarily serves as a backup to the HDRR for rates less than 1.024 Mb/s. The characteristics of the PLR used to support the collection of Spacelab experiment data in the serial mode are summarized in the following paragraphs.

B. Functional Usage

1. Recorder Function. The PLR functions in both a single recorder mode and a loop recorder mode. The single recorder mode allows for the storing and reproducing of both digital and analog data, at many rates, determined by a hardwire program plug wired for a specific mission.

   The primary recording mode for Spacelab digital data is serial record.

2. PCM Recorder Function. The recorder shall be capable of serially recording one channel of digital data during sequential tape passes. The signal to be recorded on the serial channel shall be selectable by command to be from either the "A" or "B" inputs. The "A" input is the combination of "A_1," and A_2." One or both of these inputs may be active at any given time, and the inactive source may be in the "power off" or "power on" stage. When the A_1 input is active, the data detector circuit will inhibit the A_2 input. The recorder shall dump through the dejitter buffer, without erasing the data, from one channel at a time. Digital data shall be recorded at bit packing densities of from 4.25 kb/i to 8.5 kb/i (linear inch per track).

C. Performance Characteristics.

1. Digital Data Input. The recorder shall be capable of accepting digital data, in biphase level format, at rates between 25.5 kb/s and 1024 kb/s as constrained by table 3-4.

2. Serial Digital Data Output. Serially recorded digital data may be reproduced in either direction.

3. Bit Rate Clock. Whenever serial digital data is being output at the interface connector, the recorder shall also output a clock signal at the bit rate of the data.

4. Telemetry. The tape recorder shall provide digital (bi-level) telemetry for use as status and diagnostic monitors.

5. Delay Time. The Shuttle shall be able to command three delay times out of a total of eight, seven of which are preselected at the program plug. These seven are: 0.31, 0.62, 1.25, 2.5, 5, 10, and 20 minutes. The time tolerance on the delay period is ±10 percent. The eighth delay time, equal to zero, shall always be available.

THIS PAGE DELETED.

TABLE 3-4

DIGITAL BIT RATES VERSUS TAPE SPEED

	NOMINAL (KB/S)		NOMINAL TAPE SPEED (I/PS)
	MINIMUM	MAXIMUM	
SERIAL DIGITAL CHANNEL ANY DATA RATES FROM MINIMUM TO MAXIMUMS SHOWN WILL BE DEJITTERED DURING DUMP. SERIAL DIGITAL CHANNEL WILL BE RECORDED IN SERIAL FORMAT AS INPUT FROM A_1, A_2, OR FROM B WHEN COMMANDED.	25.5	51	6
	32	64	7.5
	40.5	81	9.5
	51	102	12
	64	128	15*
	81	162	19
	102	205	24
	128	256	30*
	162	324	38
	205	410	48
	256	512	60*
	324	648	76
	409	819	96
	512	1024	120*

PRECEDING PAGE BLANK NOT FILMED

*RECOMMENDED TAPE SPEEDS FOR S/L OPERATION.

6. Run Time. The command system can select from three run times of a total of eight, seven of which are selectable by the program plug. The times are: 0.15, 0.31, 0.62, 1.25, 2.5, 5, and 10 minutes within a tolerance of ±10 percent. The eighth, continuous run time, shall always be available.

7. Tape Speeds. The four tape speeds to be commanded shall be selected by the program plug from the following: 6, 7.5, 9.5, 12, 15, 19, 24, 30, 38, 48, 60, 76, 96, and 120 inches per second. The recommended tape speeds for Spacelab operation are: 15, 30, 60 and 120 inches per second.

D. Control of the Payload Recorder. This control will be accomplished by momentary and continuous binary logic signals applied to the recorder interface and also by fixed hardwiring of the program plugs. A three-line continuous binary field selects the following functional modes: STANDBY, RCRD SERIAL "A", DUMP SERIAL, LOOP, RCRD SERIAL "B", (Analog), and STOP. A one-line momentary binary selects NO ACTION and CHANGE DIRECTION. A two-line continuous binary field selects one of four premission selected tape speeds. A two-line continuous binary field selects one of three premission selected delay times or zero delay. A two-line continuous binary field selects one of three premission selected run times or continuous run. A five-bit binary field, used as both momentary and continuous commands, selects one of six premission determined automatic sequences (cycles): erase/reset, auto interrupt/normal sequence, one of 14 Track Auto Interrupts, or Auto Interrupt/Reset. A single line continuous binary field selects the Loop Dump Mode while in the Loop Mode to dump the most recently recorded data in the opposite direction, while continuing to record in real-time. A program plug is utilized for the purpose of hardwire selection of preprogrammed sequences of recorder operation and selection of specific sets of recorder speeds, delay times, and run times.

E. Proposed Payload Recorder Configuration[5]. The PLR configuration agreed upon for early Spacelab flights and documented in ICD No. 2-05301 is as follows. The PLR shall provide the record time for recording of biphase level serial data as shown in table 3-6. The method of recording shall be by automatic serial track sequencing of 14 available tracks with turnaround interruption, as shown in table 3-6, at each end of tape travel. Recorder switch controls shall be located at the aft flight deck station for onboard operation. Control shall also be accomplished via the RF update link. The data recording interface shall be as shown in table 3-6 and the PLR signal characteristics shall be as shown in table 3-7. Capability to play back the PLR to the Spacelab shall be provided. Playback data rate is a function of the playback-to-record-speed ratio. Time for playback of the biphase level serial data shall be as shown in table 3-6 with signal characteristics as shown in table 3-7. Repro data shall be in forward or reverse direction.

TABLE 3-6

PAYLOAD RECORDER OPERATION CHARACTERISTICS

RECORD/ PLAYBACK SPEED (I/S)	DATA RATE (KB/S)	RECORD TIME PER TRACK OR PASS (MINUTES)	TOTAL RCD TIME 14 TRACKS (MINUTES)	"TURN AROUND" INTERRUPTION MAX PER DIRECTIONAL REVERSAL (SECONDS)
15	64 to 128	32	448	3.5
30	128 to 256	16	224	3.5
60	256 to 512	8	112	4.2
120	512 to 1024	4	56	6.5

TABLE 3-7

SPACELAB/PAYLOAD RECORDER INTERFACE SIGNAL CHARACTERISTICS

DESCRIPTION	SOURCE	TERM	PATCH BOARD LOCATION	TYPE	FREQ. (MB/S)	RISE & FALL	LEVEL/ VOLT	IMPEDANCE (OHMS)			QUANT. SIGNAL
								LINE	SOURCE	LOAD	
RECORDED DATA	HRM	PLR	PS	DIGI-TAL BI-O-L	*	10% OF BIT CELL TIME*	4 TP 9 PK-PK (LOADED)	70-80	71± 10%	†71± 5%	1 TSP
PLAYBACK	PLR	HRM	PS	DIGI-TAL BI-O-L	*	10% OF BIT CELL TIME**	2 TO 9 PK-PK (LOADED)	70-80	NA	71± 10%	1 TSP

*SEE TABLE 3-6
**BIT CELL TIME IS 1/DATA RATE
†COMMON MODE REJECTION: ±15V MAX. LINE TO SIGNAL GROUND

3.2.2 Command Interfaces. The Orbiter to Spacelab command interface is provided by an MDM under control of the Orbiter GPC. Ground-originated commands or computer loads are transmitted by the Orbiter GPC to Spacelab computers or subsystems via this interface. Most commands are sent to the subsystem or experiment computer by the GPC in the Orbiter. However, an alternate path from the MDM directly to Spacelab subsystems is provided for safing commands initiated by the GPC; such ON/OFF commands are routed through the remote amplifier and advisory box for signal conditioning purposes. Commands may, also, be originated at the R-7 manual control panel in the Orbiter by the crew, using switch selection procedures. The RAAB is the interface between the R-7 panel and Spacelab subsystems.

3.2.3 Caution and Warning. Spacelab has to provide to the Orbiter C&W System data which is critical to the safety of the Orbiter/Spacelab flight personnel. C&W signals are classified as follows:

- Emergency: Crew hazard, requiring immediate instinctive crew action
- Warning: Actual or impending anomalous condition which in itself is hazardous and requires immediate crew action
- Caution: Actual or impending anomalous condition which in combination with other failures constitutes a system configuration that could be hazardous to the vehicle or crew and requires action or procedural change for corrective measures.

The Spacelab C&W System is integrated into the Orbiter C&W System. The level detection of analog and discrete C&W signals is performed (software controlled) in the Orbiter GPC and in the Spacelab subsystem computer for redundancy. An overall functional block diagram of the C&W System is shown in figure 3-7 for module configuration and figure 3-8 for pallet-only configurations.

3.2.3.1 Emergency Signals and Safing Commands. Emergency signals of Spacelab apply only to fire and rapid pressure loss in the module. There are two types of sensors foreseen:

- $\Delta p/\Delta t$ sensors indicating rapid cabin depressurization
- Three redundant pairs of smoke sensors (one pair each located in the left and right side of the avionics loop, and one in the cabin loop).

The Spacelab $\Delta p/\Delta t$ sensor output is hardwired to the Orbiter C&W electronic assembly (CWEA). The input of the CWEA is connected to the Orbiter sensor only during ascent/descent and to Orbiter and Spacelab sensors on orbit. An emergency tone (klaxon) will be generated by the Orbiter CWEA when a $\Delta p/\Delta t$

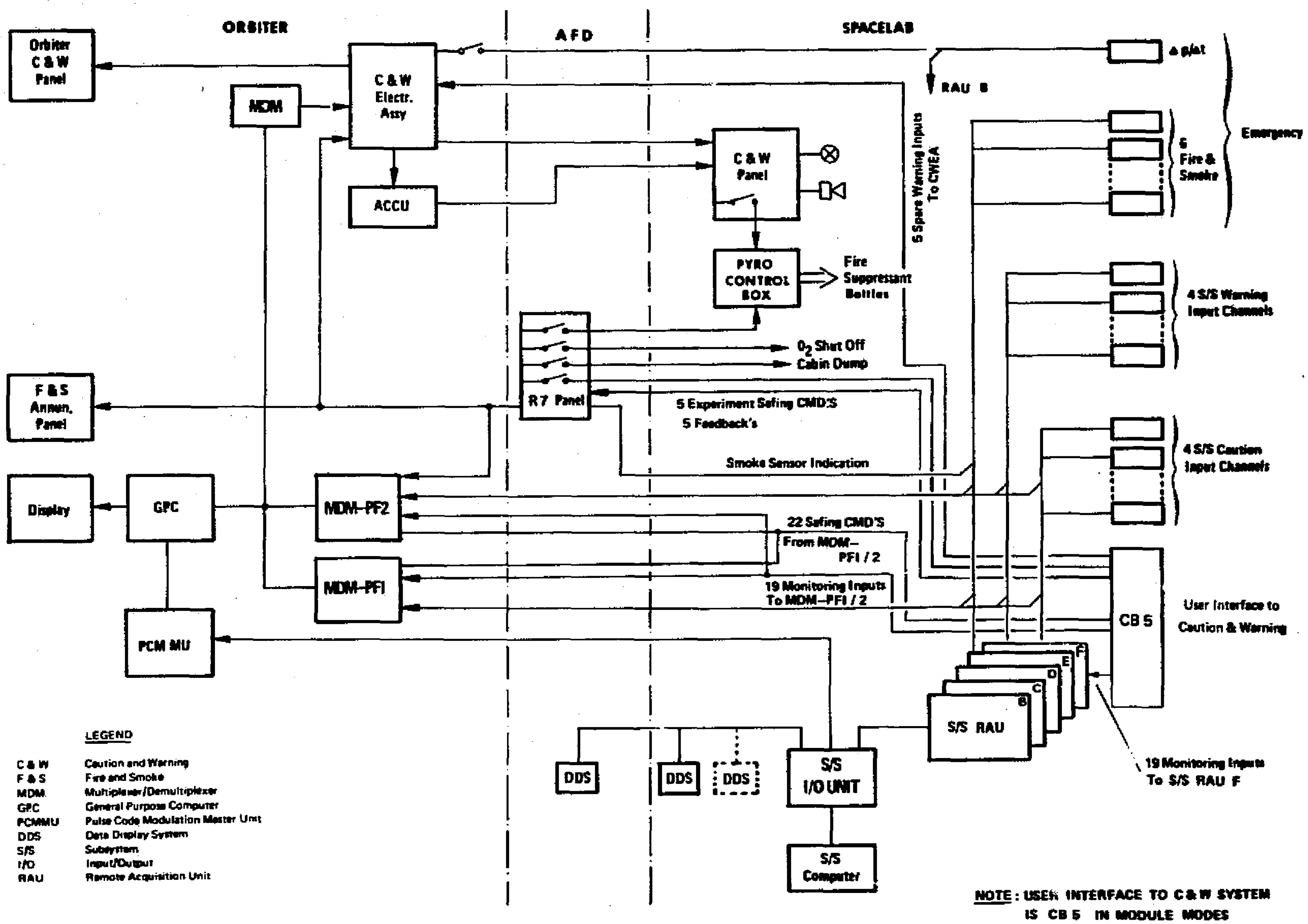


Figure 3-7 Caution and Warning Functional Block Diagram (Module Configuration)

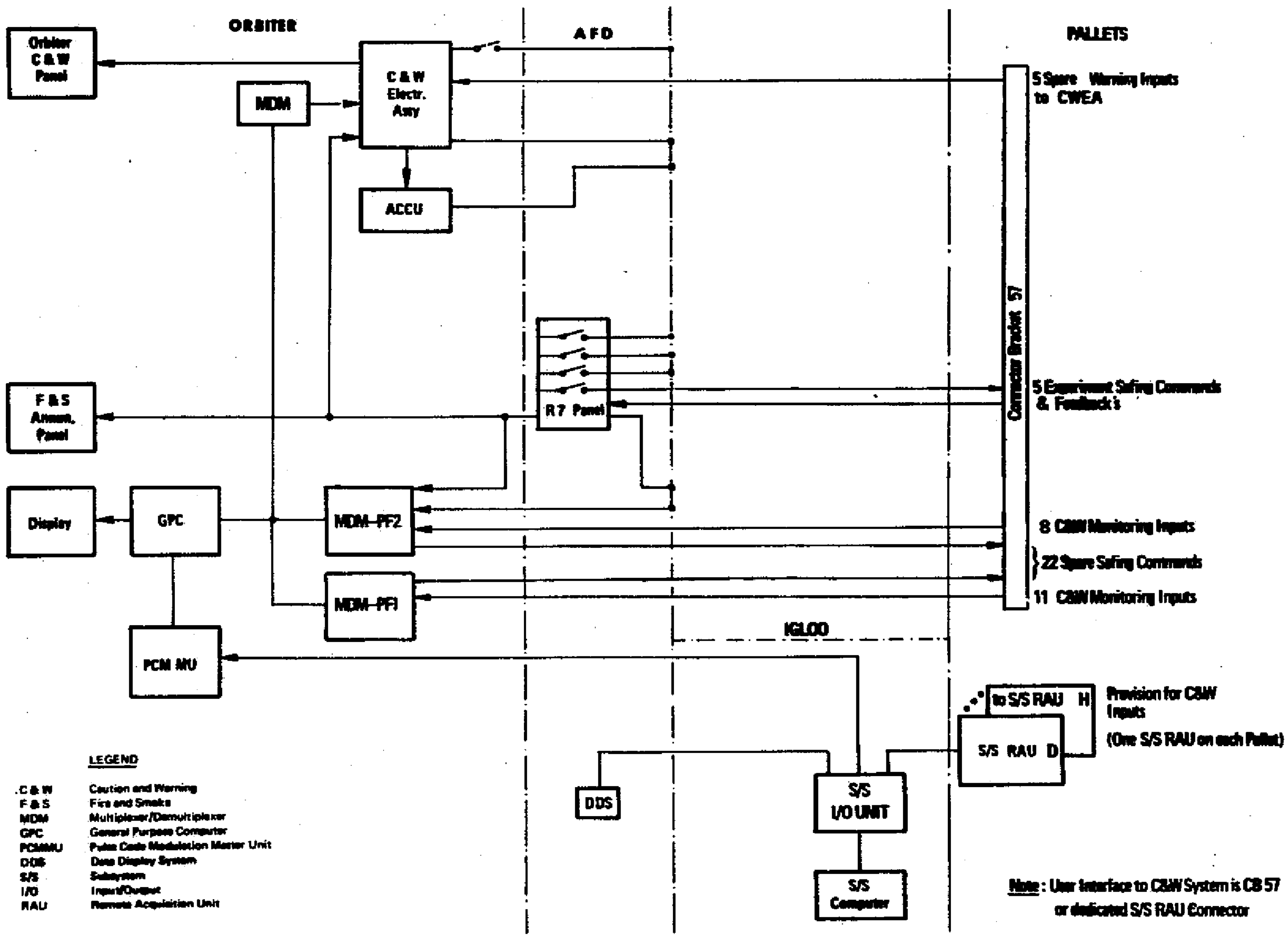


Figure 3-8 Caution and Warning Functional Block Diagram (Pallet-Only Configuration)

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

is detected. For redundancy reasons, the smoke sensor outputs are routed independently, either through the subsystem RAU's B and C to the Spacelab subsystem computer, or through the integrated monitor and control panel (IMCP, R-7 panel) to the Orbiter CWEA, to the Orbiter fire and smoke annunicator panel, and via MDM-PF 2 to the Orbiter system management GPC. In addition, fire and smoke conditions detected in the Spacelab subsystem computer are annunciated to the GPC through the PCMMU.

From the Orbiter CWEA, emergency conditions are signaled at the Orbiter C&W panel and at the Spacelab C&W/Fire Suppression System (FSS) panel in the module. To act on the detection of Spacelab fire and smoke conditions, manual switches on the IMCP R-7 panel allow for activation of the Spacelab suppression system, the O_2 shut-off valve, and the cabin dump valve. The FSS in addition can be manually activated from the Spacelab C&W/FSS panel in the control center rack. An emergency tone (siren) will be generated by the Orbiter CWEA when a Spacelab fire or smoke signal is detected.

3.2.3.2 Caution and Warning Signals. The Spacelab C&W System can accommodate C&W sensors (from a hardware viewpoint, caution signals and warning signals are treated identically). Currently there are four caution and four warning sensors dedicated to monitor Spacelab subsystems. Nineteen C&W input channels of the remaining input channels are available for experiments. In addition, five direct warning inputs to the Orbiter CWEA are available for experiments. Redundancy in detecting C&W conditions is achieved by routing the C&W sensor outputs via independent signal conditioners through either:

- MDM's PF 1 or PF 2 to the Orbiter system management GPC (C&W conditions detected by the GPC are displayed on the Orbiter display unit and the Orbiter C&W panel)

- Subsystem RAU's B, C, D, E, F to the Spacelab subsystem computer [C&W conditions detected by the subsystem computer are displayed on the Spacelab DDS. Experiment C&W sensors are connected to S/S RAU-F in module configurations, (see figure 3-7) or to the dedicated inputs of pallet S/S RAU's in pallet-only configurations (see figure 3-8)].

These two branches of the C&W System, through MDM to Orbiter and through RAU to Spacelab, are interlinked. The link from the Orbiter GPC to Spacelab for detected C&W conditions is through the CWEA and the ACCU to the Spacelab C&W/FSS panel. The link from the Spacelab subsystem computer is through the subsystem I/O unit and the PCMMU to the Orbiter GPC.

3.2.3.3 Caution and Warning Safing Comamnds. The Orbiter will provide a maximum of 36 safing commands to be used in response to Spacelab C&W conditions. These safing commands will be initiated by a keyboard entry to the GPC. The GPC issues the appropriate safing commands (discretes at voltage levels of 28 V) to Spacelab via MDM-PF 1 and PF 2. Twenty-two MDM safing commands are reserved for experiments. Five safing commands, manually switched from the R-7 panel in the Orbiter AFD, are available exclusively for experiments to act on C&W conditions.

3.2.3.4 Experiment/Caution and Warning Interface. To interface with the C&W System through the MCM and RAU inputs mentioned above, the experimenter has to provide his own sensors. To achieve a discrete or analog signal with the required characteristics, it may be necessary to provide, in addition, active signal conditioning (for the subsystem RAU and for the MDM link); these signal conditioners have to be powered by the emergency bus. Also, actuators controlled by the safing commands have to be powered by the emergency bus. The physical location of the experiment interface to the C&W System is depicted in figures 3-7 and 3-8. For module configurations, the location of these interfaces is the connector bracket CB 5. For pallet-only configurations, connector bracket CB 57 and a dedicated connector of the pallet subsystem RAU make up the interface. Connector notation, pin allocation and signal characteristics at the Spacelab/experiment C&W interfaces are given in appendix A, Avionics Interface Definition of ESA SLP/2104, *Spacelab Payload Accommodation Handbook*.

3.2.4 Voice Interface. The Orbiter Audio Distribution System and the Spacelab intercom assembly are fully integrated, employ the same headset/umbilical assembly, and have operational commonality. The Spacelab intercom system comprises an Intercom Master Station (ICMS) and an Intercom Remote Station (ICRS) as basic subsystem equipment which will fly in all module modes. Three more remote stations can be fitted into dedicated experiment racks (as mission-dependent equipment). In the short-module configuration, an ICRS is located in experiment rack 5, but in the long-module configurations, ICRS's are foreseen in experiment racks 4, 7 and 10. The ICMS has provisions to connect up to six remote stations.

The Spacelab intercom includes main and emergency dc to dc converters which are separately fixed in the ICMS for connection to the main dc and emergency dc power buses. Additionally, main or emergency dc power is distributed within the ICMS and to the ICRS's for supplying power to the Orbiter common headset umbilical assemblies, facilitating full operational capabilities from either power source.

3.2.4.1 Channel Routing. The overall channel routing capability is depicted in figure 3-9. The ICMS, which is the control and audio signal processing center of the system, interfaces with the Orbiter audio central control unit (ACCU) and Orbiter extravehicular activity (EVA)/air traffic control (ATC) transceiver (for air-to-air transmitter keying) to facilitate communications on the following full duplex (simultaneous talk and listen) audio channels:

- Air-to-Ground 1 (A/G 1)
- Air-to-Ground 2 (A/G 2)
- Orbiter/SL internal Intercom A (ICOM A)
- Orbiter/SL internal Intercom B (ICOM B)
- EVA air-to-air (A/A)
- Orbiter/SL internal page (PAGE)

Each of the above Orbiter channels, with the exception of PAGE, may be selected on each of three Spacelab full duplex channels, which are distributed via interface cards in the master station to each ICRS and the audio facility included in the ICMS.

Paging signals for general address or calling purposes originating in the Orbiter, within Spacelab, or in both locations are superimposed on each channel at a level of + 6 dB above the nominal value. The paging signals are routed to the headsets, the loudspeaker in the master station, and the remote loudspeaker unit (LSU). Access to the PAGE TALK line is obtained by operation of a special PAGE push to talk (PTT) switch mounted on all intercom stations.

Communications within Spacelab are provided by feeding back channel talk signals onto the channel listen lines for distribution to any intercom station selected to the same channel (INT channel). Spacelab channel talk and listen lines are combined for distribution to the voice digitizer in the HRM for all three Spacelab channels.

The Spacelab channel allocation and the PAGE superimposition is performed by logic circuits in the ICMS that receive discrete commands from each ICRS or the ICMS itself.

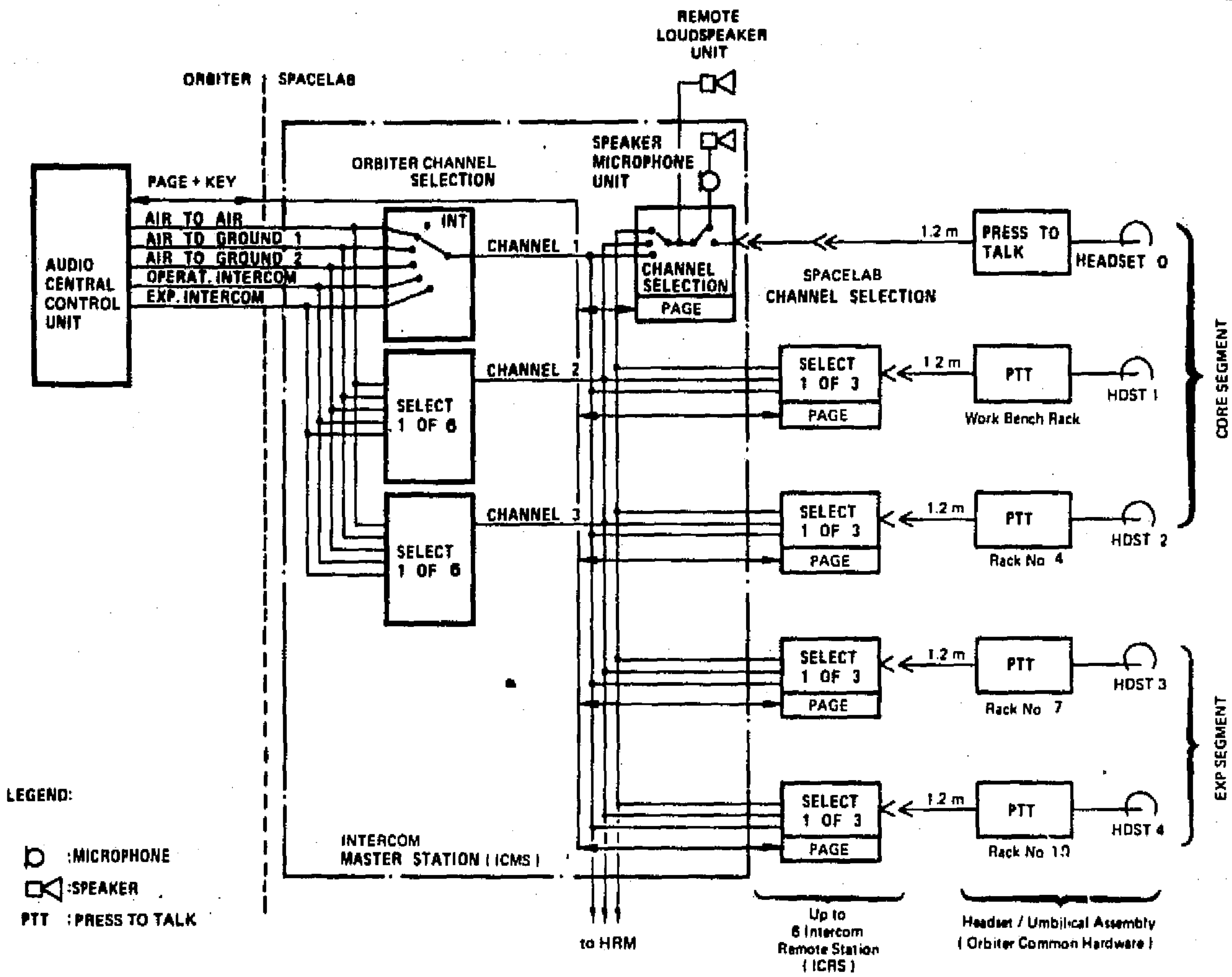


Figure 3-9 Functional Intercom Block Diagram

3.2.4.2 Audio Modes. Each intercom station (ICMS, ICRS) provides for connection of an Orbiter-type headset/umbilical assembly and includes, besides the switches for a local selection of a Spacelab channel, switches for different audio modes. The logic circuits in the master station receive discrete commands from each intercom station for channel and microphone mode selction. Microphone signals are gated onto the channel talk circuits in the following different modes.

A. PTT Mode. Available only after activation of the PTT switch in the headset umbilical or on the master station control panel, by selecting PTT and pressing biased switch.

B. VOX Mode. Available only after exceeding the voice-operated transmission (VOX) threshold, which is adjustable on the intercom control panels.

C. HOT ICOM Mode. Available continuously, but only onto the Orbiter ICOM A and B channels (if an invalid switch position is selected, the system automatically reverts to the PTT mode).

The ICMS includes, in addition to the headset which is identical to an ICRS, a loudspeaker/microphone assembly. The loadspeaker/microphone assembly can be selected in place of the remotely connected headset for channel access. In this case, however, system operation is limited to VOX or PTT and a special PTT switch is provided.

In the HDST mode, normal channel communications are provided at the ICMS via a remotely connected headset/umbilical, and the loudspeaker carries only paging signals.

With the speaker/microphone selected, normal channel communications are switched to the loudspeaker/microphone assembly (in addition to paging signals). Access to the channel talk line in this case is via a panel-mounted PTT switch. Operation of the PTT switch on the ICMS disconnects the ICMS loudspeaker for listen and PAGE. PAGE is always present on the remote loudspeaker unit.

3.2.5 Analog Data Interfaces

3.2.5.1 Closed Circuit TV System. As an extension of the Orbiter CCTV system, Spacelab provides accommodation for an experimenter-provided TV monitor and the electrical interface to operate experiment-provided TV cameras.

The experimenter-supplied camera must be synchronized with the Orbiter CCTV system. The composite video signals should have a voltage range of 0.9 to 1.1 V_{pp} with a sync tip at ±0.05 V_p, and must be compatible with EIA Standards RS 170 and RS 330. There are:

- Three inputs for experiment-provided video signals in module configurations or one input for experiment-provided video signals in pallet-only configurations
- One output for synchronization of experiment TV cameras
- One output for video signals used in the Spacelab located TV monitor (available in module configurations).

Each input or output interface is a coaxial connector, located at the Spacelab feedthrough plate in the forward endcone in module configurations, or at the igloo signal feedthrough in pallet-only configurations.

3.2.5.2 4.5 MHz Analog Channel. Spacelab provides a 3 Hz - 4.5 MHz analog channel for experiments. This channel can be used also for special non-EIA standard TV signals. The voltage range of this analog input will be 0-1 V ±10 percent. The analog channel will be a 75 Ω coaxial cable routed directly to the Orbiter KUSP.

3.2.6 MTU Interface. The Orbiter will provide pulse duration modulated time code signals and square wave clock frequency signals to Spacelab as shown in figure 3-10.

Two modified IRIG-B time code signals will be provided, one containing GMT, and the other containing MET, each of which shall be updated once per second. The absolute GMT time data shall not deviate by more than ±10 milliseconds from the ground station GMT Reference Time Standard at any time during a 7-day mission, and shall be synchronized with the ground GMT at certain times during mission, subject to mission procedural constraints, to prevent unacceptable time base perturbations. The MET will be reset to zero by the Orbiter at T-0 and shall be synchronized and updated from the ground.

The Orbiter will provide four (1024 kHz, 4608 kHz, 1 kHz, and 100 kHz), square wave clock signals to Spacelab.

A more detailed description of the Orbiter Time Distribution System is presented in paragraph 3.1.8.1.

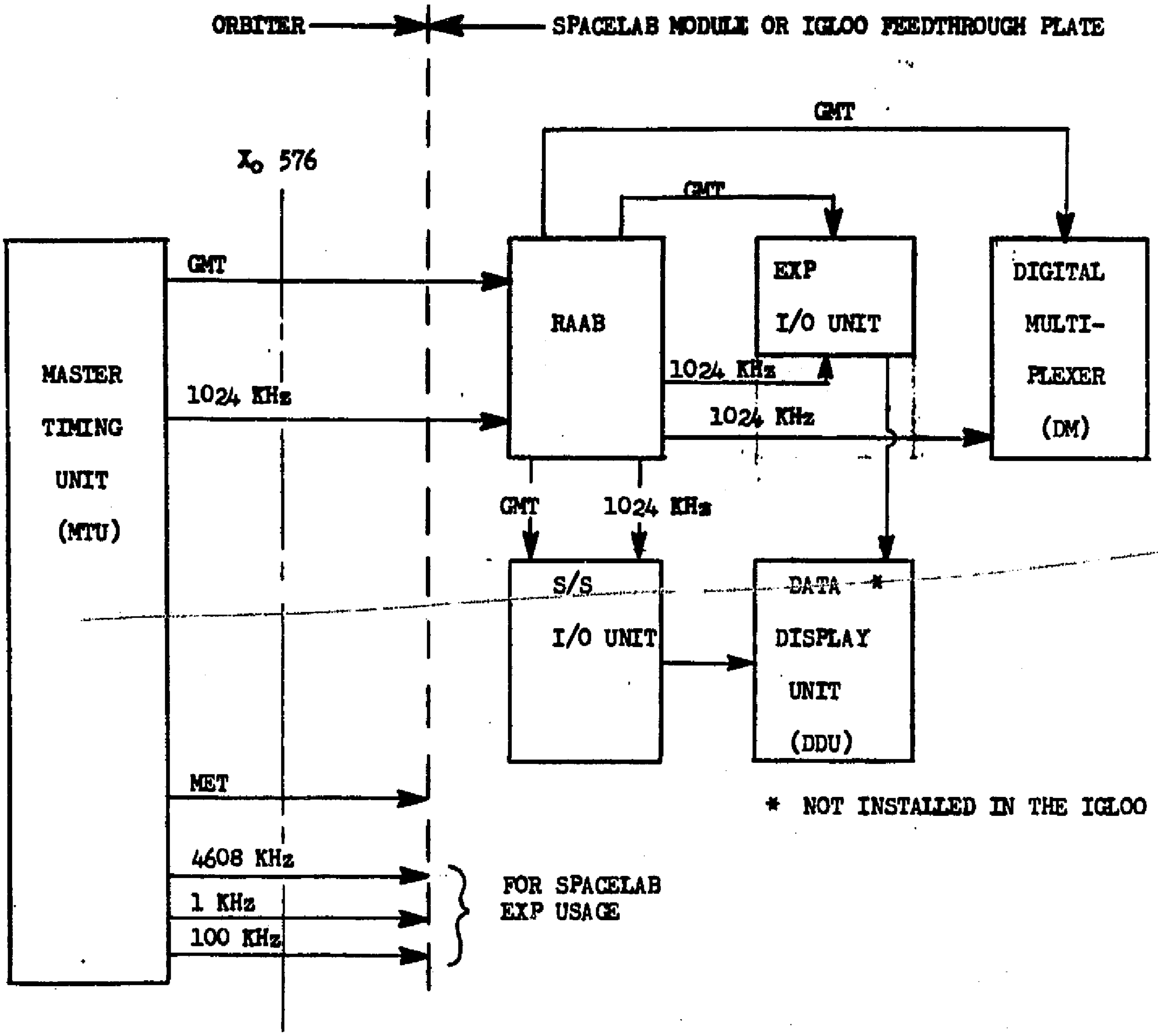


Figure 3-10 Timing Signal Interface

SECTION 4

ORBITER/SPACELAB TELEMETRY DATA FLOW

4.1 GENERAL

Spacelab represents a dramatic increase in both the rate and volume of telemetry data to be handled by ground support systems. Additionally, the diverse range of experiments and their associative ground processing requirements for monitoring, command, and control purposes represent a significant challenge in the area of flight-to-flight reconfiguration and checkout. The number of possible data formats has become extensive due to the increased use of computer equipment and microprogrammable hardware onboard the space vehicle. Recent reductions in size, weight, and power requirements for this equipment have now made it feasible for a single experimenter to incorporate data processing functions within his experiment package that are capable of many modes of operation.

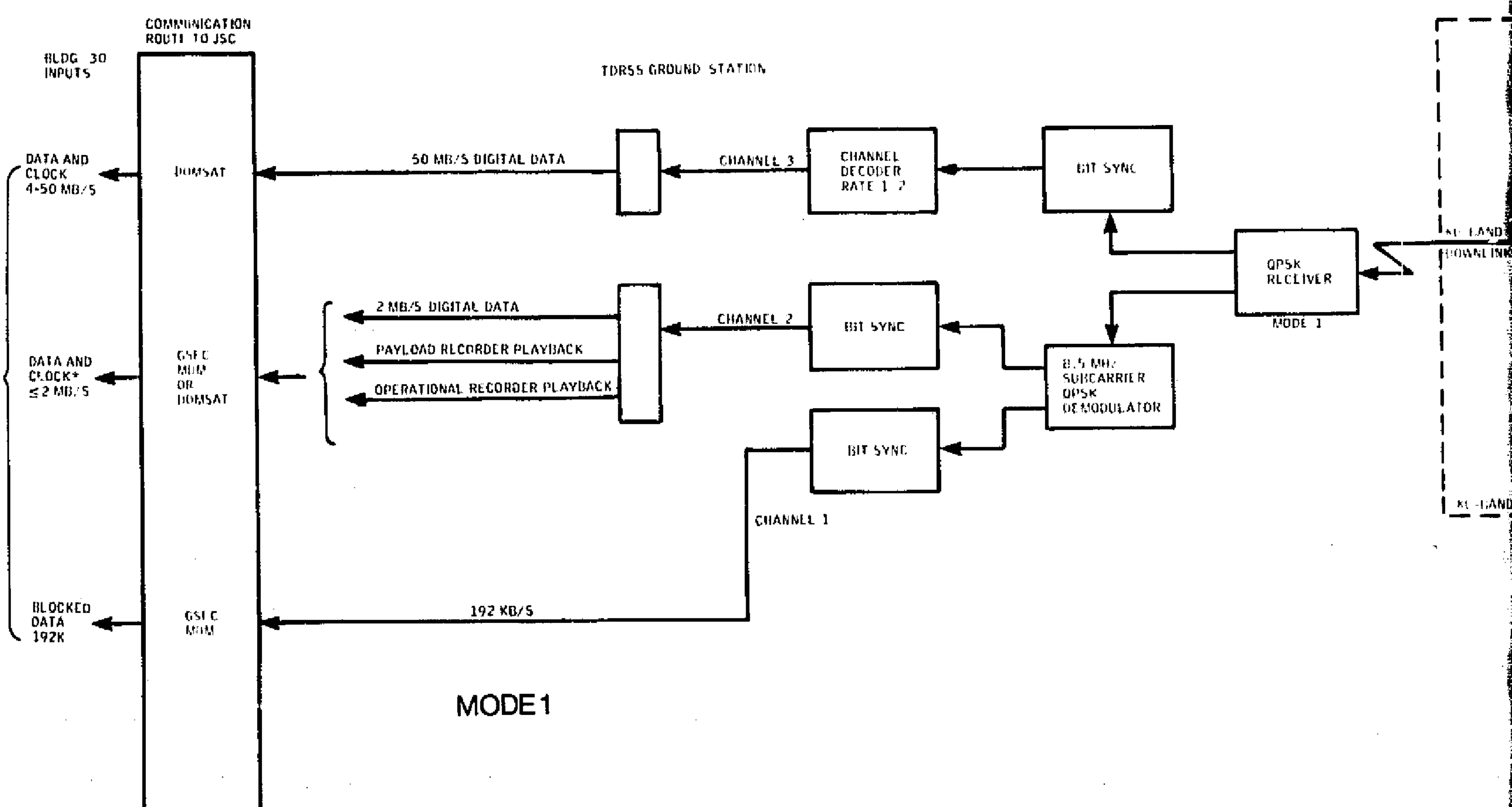
The majority of Spacelab telemetry data originates in the experiments themselves; the major exception is the Spacelab Subsystem Computer Downlist. This telemetry data is acquired and formatted by a complete computer system with dedicated hardware interfaces for monitoring and control of the Spacelab subsystems not dedicated to experiment-unique functions.

A single experiment may vary in complexity from a one sensor to a complete data acquisition, processing, and telemetry formatting system. The number of experiments that can be accommodated is limited only by the switching network to be implemented onboard.

The avionics diagrams in figures 4-1 and 4-2 depict the telemetry data flow paths from the Shuttle Orbiter in a Spacelab configuration to the ground, for modes 1 and 2. There are two primary paths for telemetry flow from experiments and onboard computers: the low data rate path via the PCMMU for interleaving into the operational downlink and the high data rate path via the HRM.

FOLDOUT FRAME

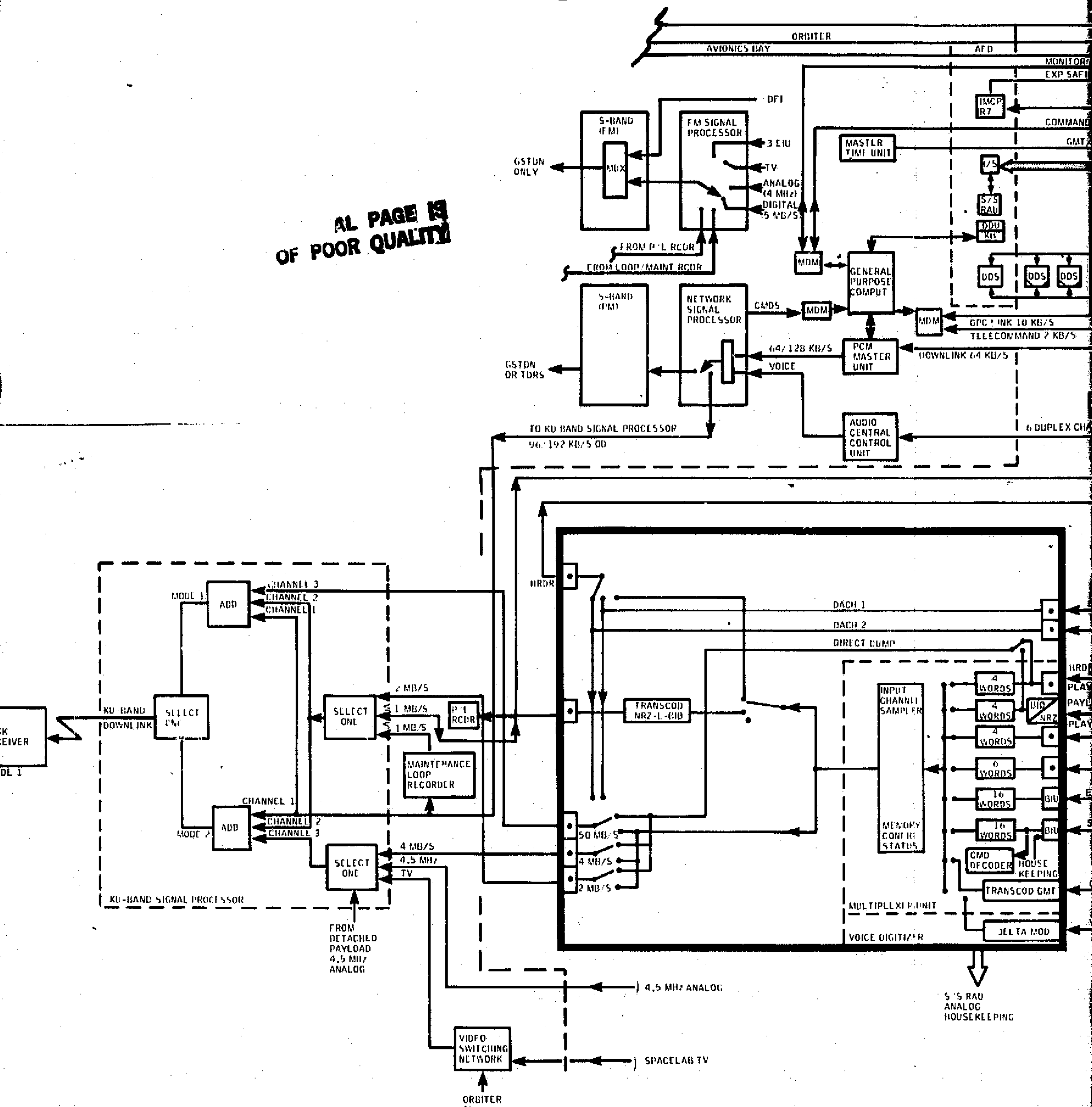
ORIGINAL PAGE IS
OF POOR QUALITY

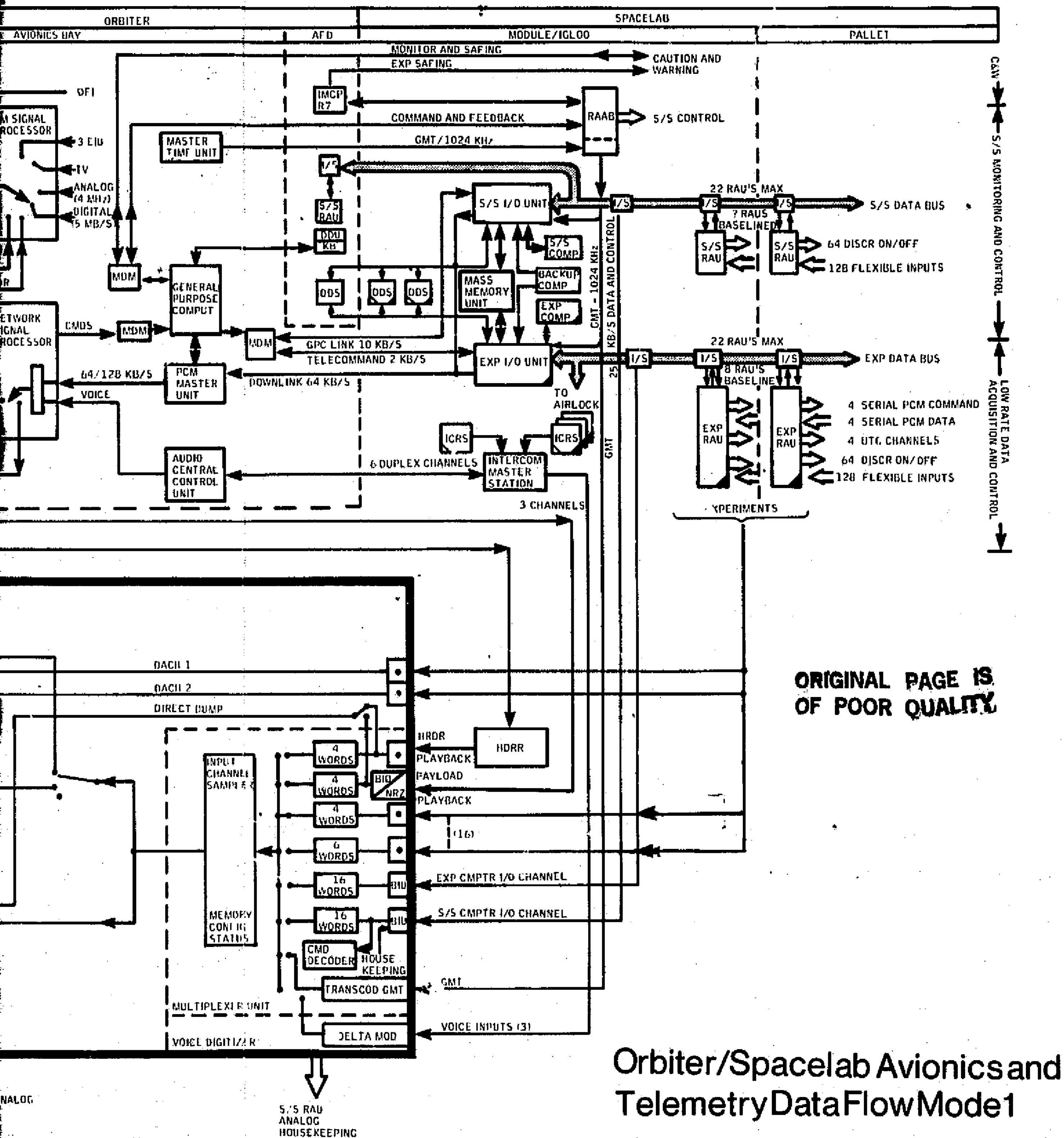


MODE 1

FOLDOUT FRAME 2

AL PAGE IS
OF POOR QUALITY



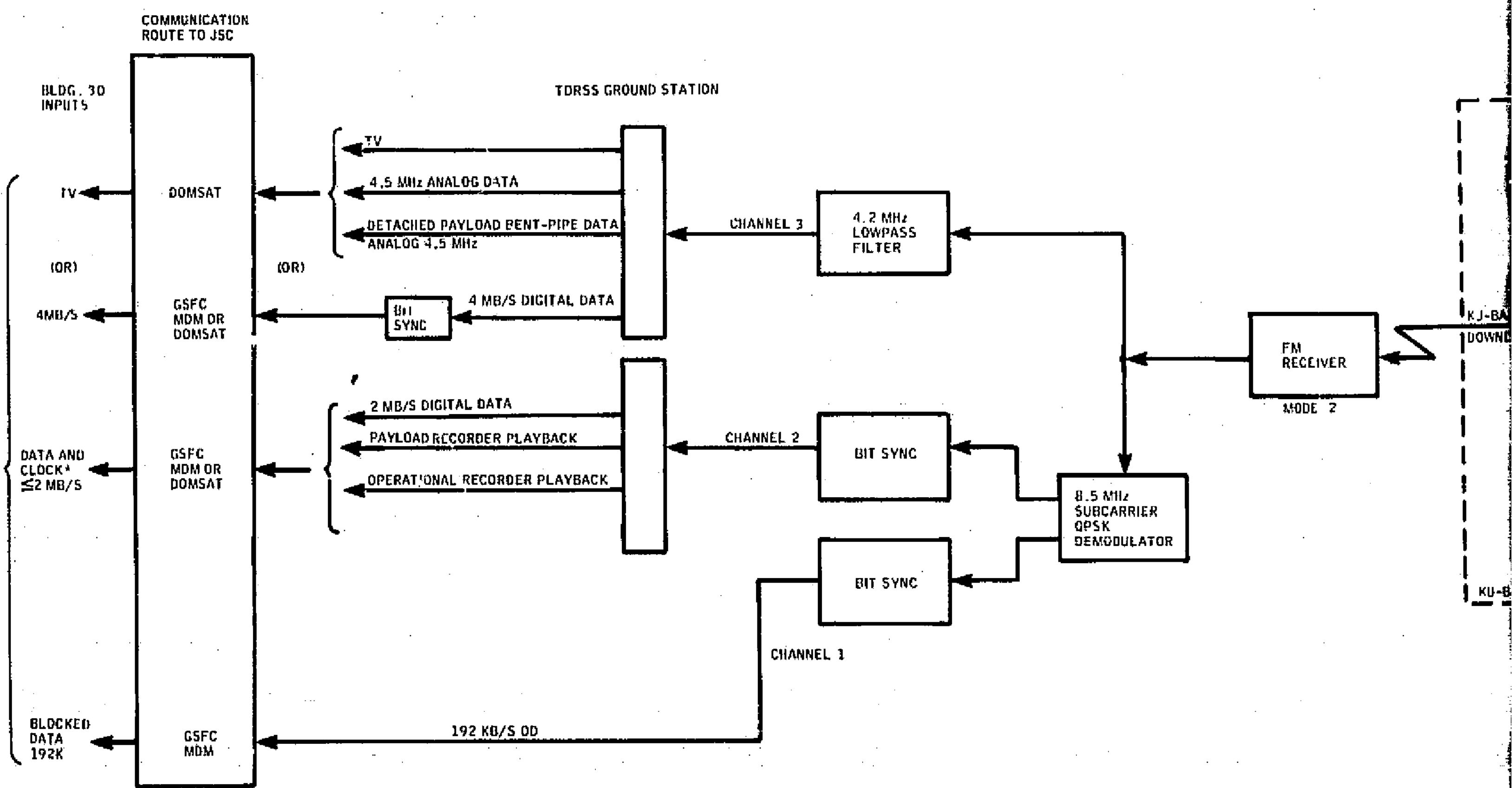


AA10905(D)-3

Figure 4-1 Mode 1 Telemetry Data Flow Paths from Orbiter to Ground (Spacelab Configuration)

FOLDOUT FRAME

ORIGINAL PAGE IS
OF POOR QUALITY

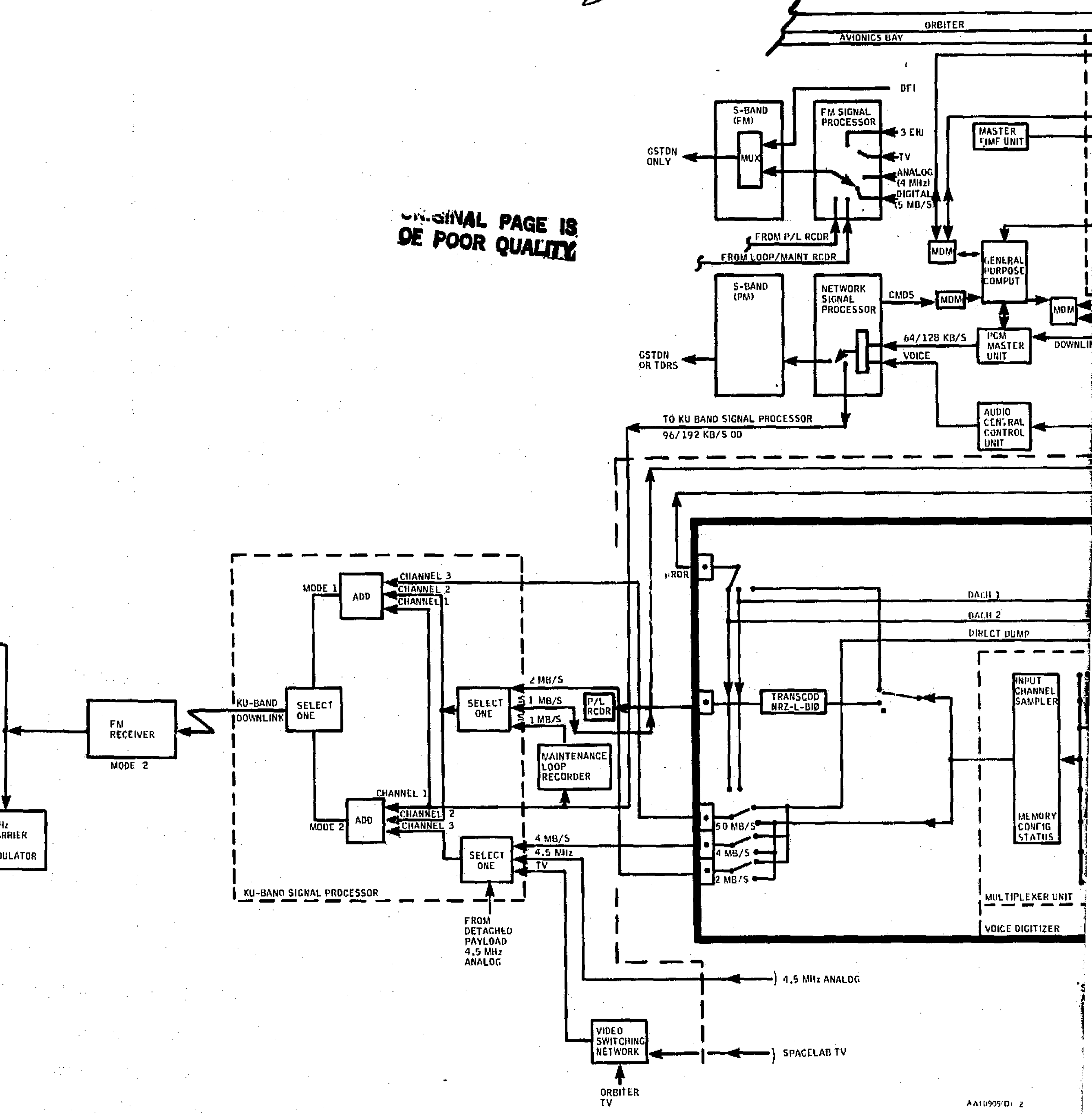


*ASSUMES USE OF GSFC SERIAL MDM OUTPUT IF COMM ROUTE IS GSFC MDM

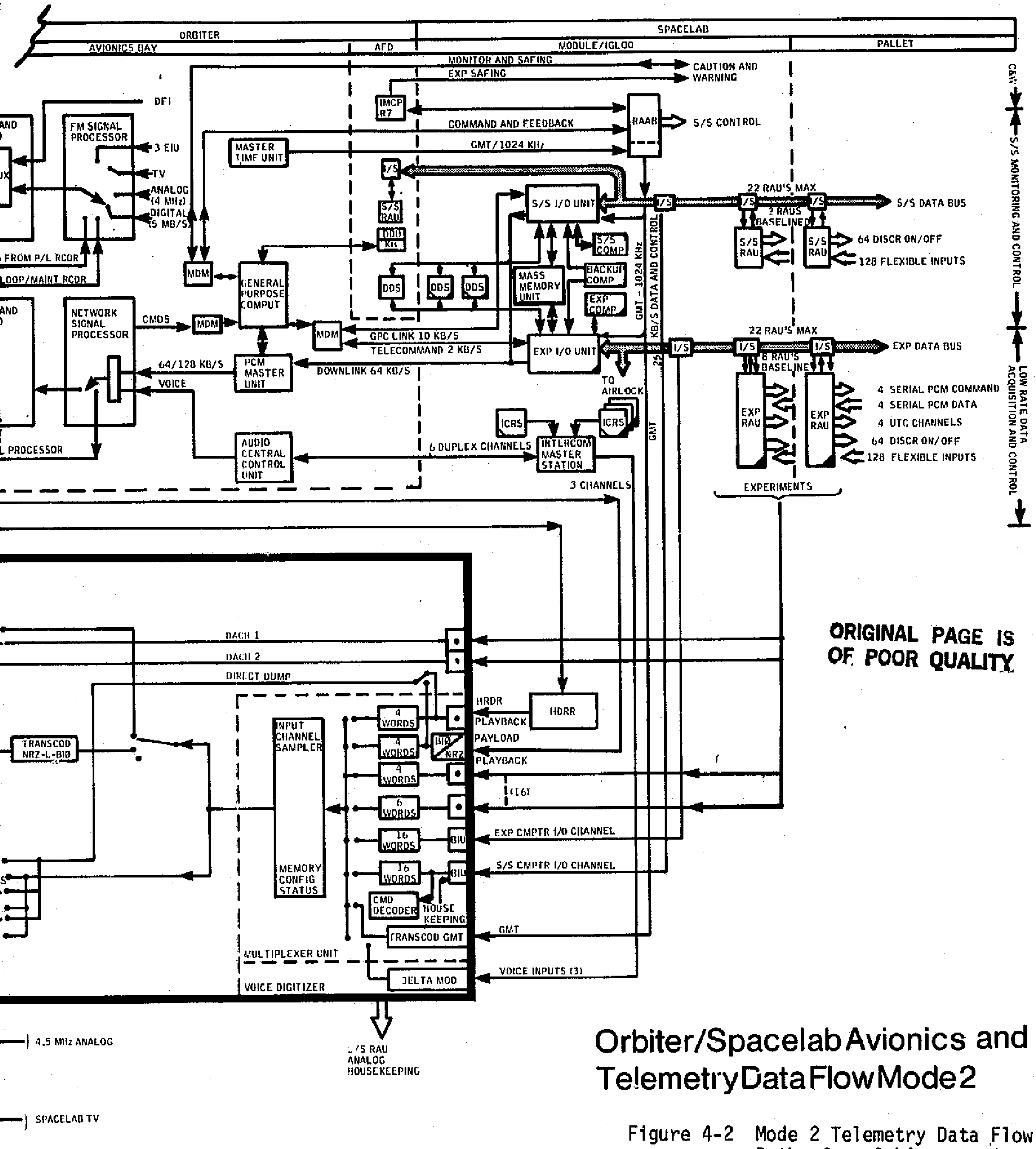
MODE 2

FOLDOUT FRAME 2

ORIGINAL PAGE IS OF POOR QUALITY



AA10905(D) 2



ORIGINAL PAGE IS OF POOR QUALITY

Figure 4-2 Mode 2 Telemetry Data Flow Paths from Orbiter to Ground (Spacelab Configuration)

4.2 SPACELAB/PCMMU DATA FLOW

The RAU's are the principal interfaces for the bidirectional link between experiments and the CDMS for acquisition of low-bit-rate digital data, analog data, and distribution of commands. The data exchange between RAU's and the I/O unit is performed via simplex serial buses with a 1 Mb/s clock rate. The data is encoded in a self-clocking bi-phase code (Manchester II).

For a single serial channel, the RAU can handle a data rate of up to 50 kb/s. However, for the entire payload, the overall data bus load together with the overall computer load imposes additional constraints, which are to be taken into account.

Low-rate-data acquisition from experiments and experimental control is performed by the experiment computer through the experiment I/O unit, the experiment data bus, and experiment RAU's. Data processed by the computer may be transmitted to the ground via the Orbiter PCMMU. The low-rate data link is designed to achieve a word error rate (WER) $\leq 1.7 \times 10^{-7}$ for the data flow between any RAU digital input and the Orbiter PCMMU. In addition, the PCMMU provides the interface through which Spacelab data may be sent to the Orbiter GPC.

The fetch subsystem of the PCMMU issues data fetch commands (up to 2000 per second) to both the subsystem and experiment computer IOU's in the Spacelab. The IOU responds to each fetch command by reading data words (up to 10 per command) from the computer memory and transmitting the data back to the PCMMU, where it is placed in a RAM accessible by the OD telemetry formatters and by the Orbiter GPC's. The sequence in which commands are issued and the RAM locations in which data is stored are premission-defined and cannot be changed in flight. A more detailed write-up of this sequence may be found in appendix E of this document, along with a proposed minimal set of parameters to be acquired by the PCMMU from the subsystem computer.

Although the onboard operation of this interface is very straight-forward, the following concerns have resulted during the conduct of this study.

4.2.1 Spacelab/PCMMU Data Flow Concerns

4.2.1.1 Spacelab Computer Software Configurations. The implications of multiple load configurations affect not only the POCC but existing Orbiter ground processing systems as well. Each computer provides a fixed 2K segment of its memory for PCMMU access; fetch commands from the PCMMU can access only these physical memory locations. However, multiple software configurations can result in different measurements being placed in the 2K memory segment of the GML application. Therefore, the content of the Spacelab dedicated portion of the OD downlink is variable, and is dependent on the Spacelab computer load configuration. The impact can be minimized by adopting one or more of the following ground rules, and it becomes negligible if all are adopted.

A. A parameter which is transferred to the PCMMU in more than one configuration be assigned the same memory address across all configurations.

B. A measurement defining the software configuration be defined and sent to the PCMMU in all configurations; the parameter must be downlinked in all OD formats.

C. A unique OD format be used for each combination of EC and SSC load configurations.

4.2.1.2 Bandwidth Allocation of Spacelab Data in the OD. It is highly desirable that flight control be given priority in the bandwidth allocation for Spacelab data in the operational downlink. This would eliminate the necessity for routing and processing of the Spacelab I/O downlists from the HRDM by existing Orbiter ground support systems. It should be noted that 320 kb/s of Spacelab data can be acquired by the PCMMU; OD bandwidth allocation is nominally 64 kb/s of that data in a given OD format. Therefore, the data acquisition and downlink capability is equal to that of the OI capability. Based on that fact, it seems reasonable to suggest that all of the Spacelab data required by Flight Control could be contained in the OD and be processed by existing capability.

All data acquired by the PCMMU from the Spacelab computers will be redundantly downlinked via the computer I/O to the HRM path. Although some of the parameters might be rate-reduced by the computer downlist software, this allows POCC access to the parameters contained in both the OD and computer I/O telemetry streams.

4.3 SPACELAB/HRM TELEMETRY DATA FLOW

The high-rate data acquisition part of the CDMS is capable of time-multiplexing digital experiment data from up to 16 different sources with a data rate of up to 16 Mb/s, together with data from the CDMS computers, voice, and onboard time. To bridge mission periods with no downlink capability, the high-rate data acquisition assembly includes digital recorders and provisions to interleave the playback data into the real-time data stream. A single source can be accepted with a data rate of up to 50 Mb/s for direct transmission, and a data rate of up to 32 Mb/s for recording. The high-rate data acquisition assembly comprises the following equipment (see figure 4-3).

A. Onboard

1. The HRM to time-multiplex the input data and to perform the routing of the composite output data stream to one of the two recorders and/or one of the three Ku-band processor (KUSP) inputs. In addition, the HRM includes a voice digitizer to collect and also multiplex the data from the Spacelab voice channels.

2. The HDRR to store data at rates up to 32 Mb/s during mission periods which have degraded downlink capability or none at all.

3. The PLR (Orbiter equipment) serving as backup for the HDRR for data rates up to 1024 kb/s.

B. On the Ground. The HRDM to demultiplex the composite data stream to recover on the ground the same channels as presented at the HRM inputs onboard.

4.3.1 CDMS Computer Links. The HRM is connected with the CDMS subsystem and experiment computers by means of the subsystem and experiment data buses. The bus interface units (BIU's) in the HRM are similar to built-in RAU's. As such, they are addressed by the computers like standard RAU's. Data from the computers to the HRM is transferred as "serial PCM commands." The principles of the HRM/computer links are shown in figure 4-4.

Control, monitoring, and configuring functions of the HRM are performed by the subsystem computer only. The subsystem BIU part of the HRM is capable of detecting commands in the incoming data stream, and is capable of sending housekeeping data from the HRM to the subsystem computer. The experiment BIU part of the HRM serves for data transfer from the experiment computer to the HRM only.

The HRM contains 16-word input buffers at the CDMS computer input channels. Thus, blocks of up to 16 words can be transferred by GML cycle. Assuming a 10 ms GML cycle, this results in an effective data rate of up to 25.6 kb/s.

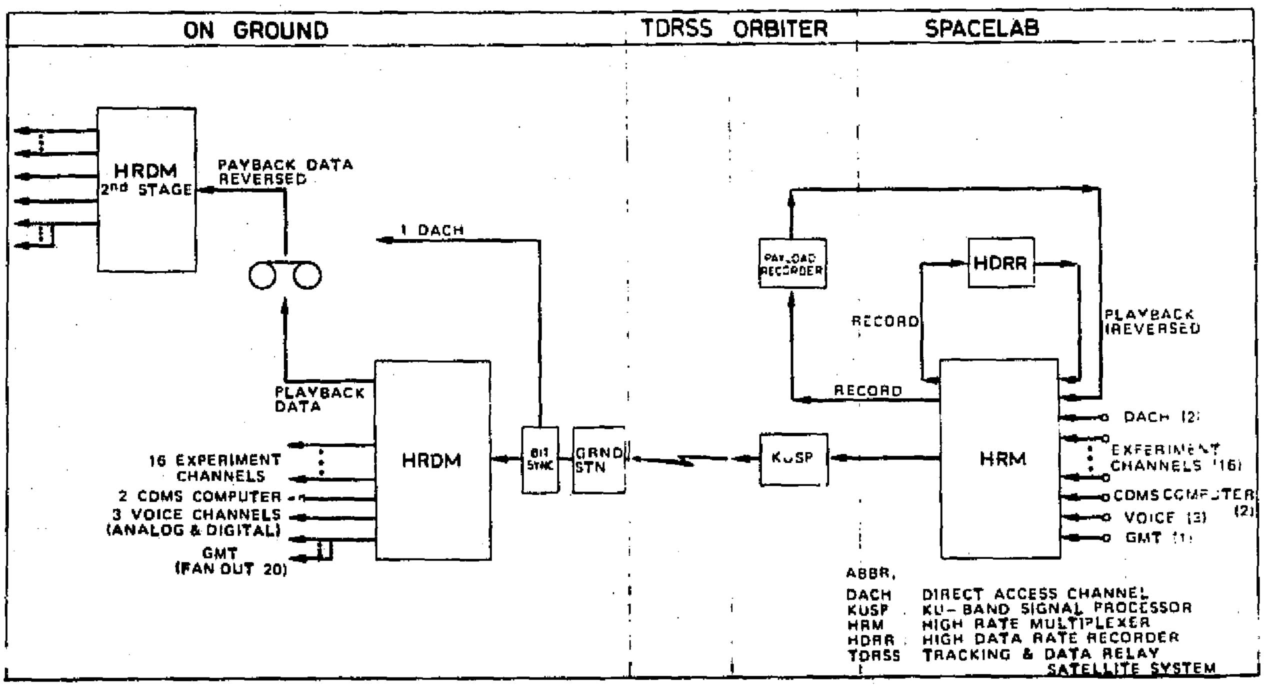


Figure 4-3 High-Rate Data Acquisition Data Flow

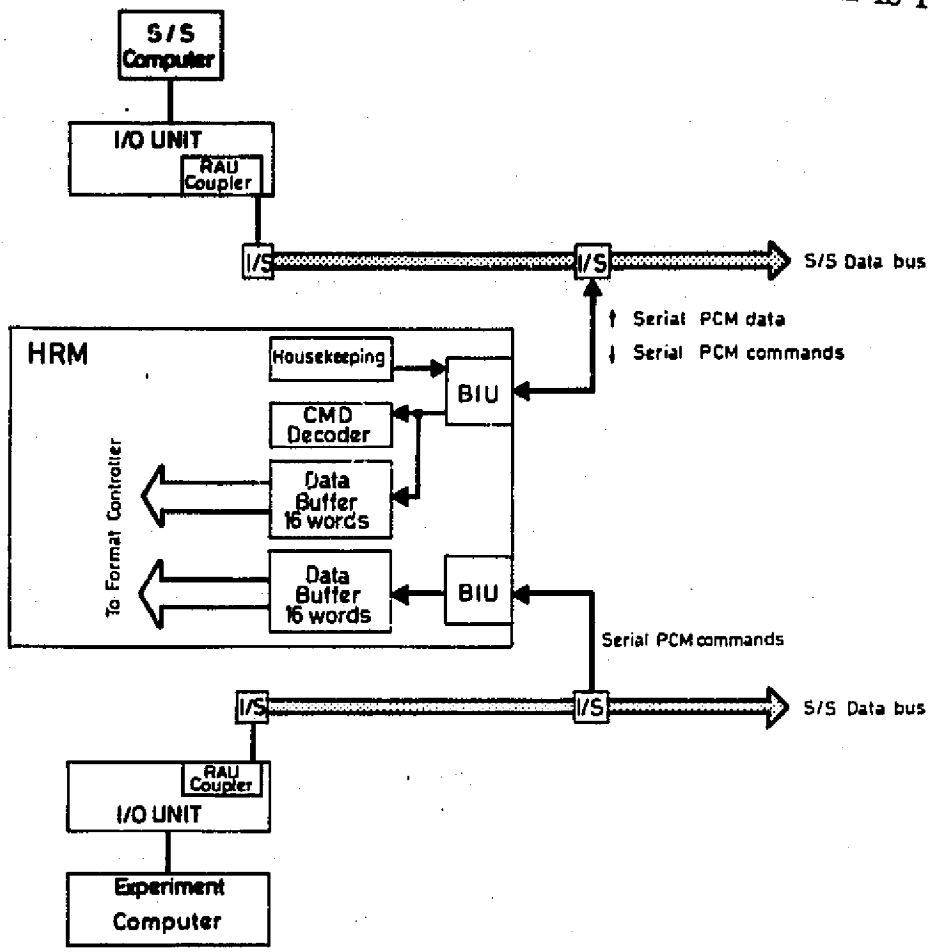


Figure 4-4 HRM/Computer Links

Using an HRM format that allocates a nominal data rate of 1 Mb/s to the HRM data bus input, the HRM can accept any possible multiple of 32-word blocks within a GML cycle. In this case, the size of the input buffer is no longer the limiting factor because with 1 Mb/s allocated, the input buffer is emptied faster that it is filled. More efficient channel usage may be obtained by distributing the word blocks of data across the full period of a 10 ms GML cycle, thus reducing the allocated nominal data rate required.

4.3.2 Onboard Experiment Data Processing. The CDMS has three identical MITRA 125/MS general-purpose computers. The three computers are used as a subsystem computer, experiment computer, and backup computer. The subsystem and experiment computers are connected to the dedicated CDMS equipment, each via its own I/O unit, data bus, and RAU's. There is no direct link between the computers. The third computer is available as a backup either for the subsystem or experiment computer, and can be switched over manually.

The computer facilities allow general-purpose processing by user-provided software written in HAL/S or another appropriate language for such purposes as:

- Checkout of experiments
- Sequencing of experiment operations
- Monitoring and control of experiments
- Processing of data acquired by experiment RAU's.

Examples of data processing are filtering, data reduction, histograms, averaging, and interpolation, etc. The processed data may be delivered back to experiments, displayed onboard, or transmitted to ground, depending upon the mission requirements.

For experiment sequencing, the user may provide several program packages for each experiment stored in the MMU. Depending on actual experiment results or data and information from ground via keyboard entries or directly via uplink commands, a running sequence of operation steps may be stopped or changed or a new program may be initialized to be executed in the experiment computer.

4.3.3 High-Rate Multiplexer. The HRM provides experimenters with the interface for high-rate telemetry data from experiments to the ground. Rates of 16 Mb/s can be accepted from a single experiment and multiplexed with other experiment data to form a composite telemetry output format of ≤50 Mb/s. Additionally, two direct inputs at the HRM are available through which data of ≤50 Mb/s can be routed directly to the ground (not multiplexed with other data) or to onboard recording equipment.

The most important aspect of this box is that the individual experiment format (other than bit rate) is not a factor in the multiplexing process. This fact is stated to amplify the need for some formatting standards to be levied on the scientific community.

Data is collected and multiplexed (or throughput) at the HRM from the following sources:

- 16 experiment channels at $\leq$ 16 Mb/s each
- Two direct-access channels at $\leq$ 50 Mb/s
- Two recorder playback channels (the HDRR at $\leq$ 32 Mb/s, and the PLR at $\leq$ 1.024 Mb/s)
- One GMT channel at 1024 kHz
- Three voice channels at 32 kb/s each
- Two computer I/O channels at 25.6 kb/s each (see paragraph 6.3).

Several combinations and output formats are derived from these 26 input channels and are discussed in the HRM analysis (appendix I of this report).

The HRM accommodates three voice channels, coming from the SL intercom master station in module configurations and, if required, from the Orbiter ACCU in pallet-only configurations. A built-in voice digitizer performs the necessary analog/digital conversion of the three voice channels and the time division multiplexing of the digitized voice signals. The voice digitizer transforms each analog voice signal to a 32 kb/s digital signal; delta modulation is used for A/D conversion.

4.3.4 HRM Data Routing. The overall data routing capability can be seen in figure 4-5; in particular, the HRM is capable of performing the following routing configurations:

A. Multiplexed experiment data routed to one of the three KUSP inputs for real-time transmission.

B. Multiplexed experiment data recorded on one of the two recorders (simultaneously with real-time transmission, if required)

C. HDRR output routed directly to one KUSP input and multiplexed data stream switched off or routed to another KUSP input or recorded on payload recorder.

D. Same as C, but the functions of HDRR and PLR are interchanged.

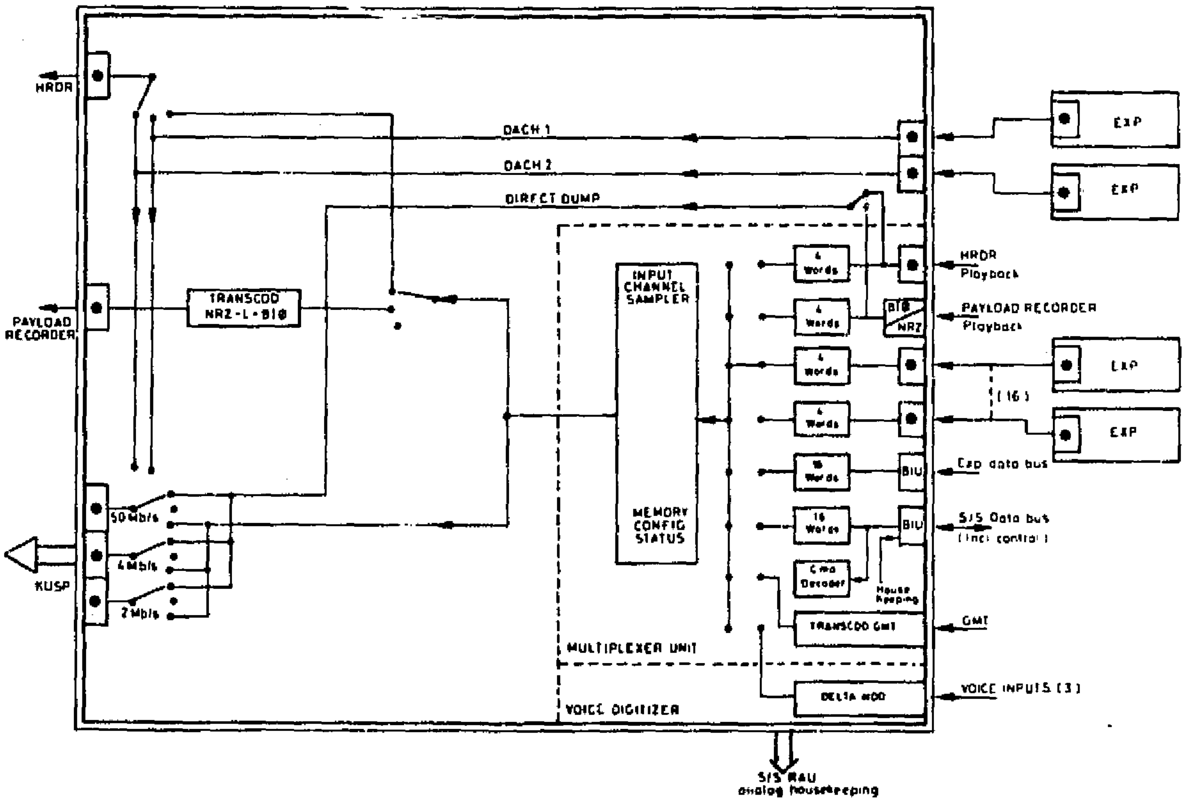


Figure 4-5 HRM Block Diagram

E. Direct access channel routed to the two 50 Mb/s KUSP input, and multiplexed data stream switched off or routed to another KUSP input or recorded on one of the two recorders.

F. Direct access channel routed to the HDRR and recorded, and multiplexed data transmitted in real-time or recorded on PLR.

The HRM routing modes will be commanded by the subsystem computer via the subsystem data bus and the BIU interface dependent on downlink availability, Ku-band signal processor operation mode, and multiplexed data rate.

4.3.5 High-Data-Rate Recorder. The principal function of the HDRR is to provide for intermediate recording of experiment data during interrupted Orbiter-to-ground TDRSS transmission times. Besides this, the experimenter may record his experiment or housekeeping data for onboard storage.

The HDRR and the HRM will form an integrated system. Both are controlled by the CDMS subsystem computer in a coordinated manner. The experiment interfaces with the HDRR via the HRM only. During record and playback, the HDRR will be externally synchronized by the HRM clock.

The HDRR will be used as a buffer during TDRSS noncoverage times or Ku-band modes with bit rates below the HRM output bit rate. During playback, the recorded data can be interleaved into the real-time data stream through a recorder dedicated input channel of the HRM.

Data recording for onboard storage without transmission to the ground is possible only during periods when nonbuffer capacity for transmission gap times is required. In this case, the tape change capability of the HDRR may be useful for the experimenter.

Since the HDRR can play back only in the reverse direction, a two-pass operation on the ground is required to process HDRR playbacks. On the first pass, the HDRR output of the HRDM (bypass or normal output channel) will have to be recorded on a ground recorder. Playing the ground recorder in the reverse direction will present the data in the forward direction for demultiplexing in the HRDM decommudation, and preprocessing in the JSC POCC.

4.3.6 Payload Recorder. As backup for the HDRR, the Orbiter-provided PLR can be used. This recorder will have a storage capacity of 3.44×10^9 bits and an input rate selectable from 25.5 to 1024 kb/s. The method of recording is serial track sequencing of 14 available tracks with turnaround interrupts between 3.5 and 6.5 seconds. The record time per track varies from 32 minutes to 4 minutes.

4.4 ORBITER-TO-JSC DATA FLOW

4.4.1 Ku-Band System. The Spacelab communications with the ground are provided by the Orbiter Ku-band System. The Ku-band communications are via a single, directional, tracking antenna that requires less of Ku-band communications for satellite hardware. The Ku-band System operates in one or two modes (modes 1 or 2) and in each mode, three services are available -- channels 1, 2, or 3. Table 4-1 shows the Orbiter communications capabilities for each channel in both modes.

Summarizing this table in terms of support of Spacelab, we have the following:

CHANNEL	MODE 1	MODE 2
1	192 kb/s operational data	192 kb/s operational data
2	125 kb/s to 2 Mb/s	125 kb/s to 2 Mb/s
3	2 Mb/s to 50 Mb/s	TV or analog or 125 kb/s to 4 Mb/s

4.4.2 TDRSS Communications. This data is transmitted to the TDRSS and subsequently to the ground. The TDRSS then demodulates and decodes the data, providing it to the NASA interface. The TDRSS ground station must be cognizant of the received data rate on each channel and will require manual reconfiguration time between rate changes.

Figures 4-1 and 4-2 provide a functional description of the TDRSS data flow. The TDRSS modes and channels are summarized in table 4-1. The TDRSS contractor (WUI) outputs to NASA data on a per-channel basis. The TDRSS ground station provides some quality indicators to the Ku-band users. These include received signal strength, demodulator lock (mode 2) and an estimated bit error rate (BER) of channel 3, mode 1. The estimated BER is derived by the Viterbi decoder. For digital data that has been decoded or synchronized, the WUI/NASA interface is data and clock. The analog/video interface of mode 2, channel 3, is 75 ohm unbalanced. For digital use of mode 2, channel 3, the synchronizing is accomplished on the NASA side.

4.4.3 NASA Interface Monitoring System. It has been baselined that NASA/GSFC will provide to JSC a data qualtiy check of the OD data as it comes from WUI to NASA but before it enters any communications equipment. The baselining of similar quality checks for the higher-rate science data has not been done because the nature of the data which will be placed on these links is unknown. Currently, there is an effort underway to establish a baseline for performing similar quality monitoring functions on these links as well. For digital links compatible with standard frame synchronization techniques, these quality

TABLE 4-1

MODE AND CHANNEL CAPABILITIES

KUSP MODE 1 (PM MODE)		
CHANNEL 1	CHANNEL 2	CHANNEL 3
192 KB/S OF OPERATIONAL TDM	16 KB/S TO 2 MB/S OF DIGITAL DATA USED FOR: • OPERATIONAL RECORDER PLAYBACKS • PAYLOAD BENT PIPE DATA • PAYLOAD RECORDER PLAYBACK • ATTACHED PAYLOAD (INCLUDING SPACELAB)	2 MB/S TO 50 MB/S OF DIGITAL DATA THIS CHANNEL IS ENCODED (K=7, R=1/2)
KUSP MODE 2 (FM MODE)		
CHANNEL 1	CHANNEL 2	CHANNEL 3
SAME AS MODE 1	SAME AS MODE 1	TELEVISION OR ANALOG TO 4.5 MHZ OR DIGITAL DATA TO 4.0 MB/S

checks will be related to minor frame synchronization validation (e.g., valid frames/second). This is frame synchronization on the total digital PCM channel and not on individual experiments in the HRM. For analog links, the checks, if any, will be manual and subjective.

There is no planned DQM of Payload or HDRR dumps at this interface. Recorder dump data quality will be assessed at JSC.

The most probable method of providing DQM data to JSC is by adding these parameters to the Orbiter as a once-per-second status message which is displayed in the MCC.

4.4.4 S-Band Transmission. The S-band FM transmitter interfaces only with the GSTDN. Data types that can be transmitted via this link are recorder dump of the maintenance recorder, payload recorder dumps, main engine data, television, and digital payload data. There is no GSTDN requirement to support this link after the TDRSS is operational.

The S-band (PM) transmitter interfaces with the GSTDN and TDRSS. Data types that can be transmitted are the 96 kb/s version of the OD. There is currently no requirement for GSTDN to support this Orbiter interface after TDRSS is operational.

4.4.5 White Sands/JSC Communications. The MDM communications system between White Sands and JSC has been developed primarily for the operational links (192 kb/s real-time and 960 or 1024 kb/s dumps). The higher rates have not been specifically addressed to date.

The MDM's total capacity is expandable up to more than 6 Mb/s with serializer output capability planned for individual links up to 4 Mb/s.

For rates above 4 Mb/s. a digital channel via a DOMSAT will be used. It is planned that the DOMSAT channel will be leased at a rate above the highest Spacelab data rate. A rate change technique will be used to convert the various Spacelab rates to the DOMSAT rate and will return those links to the original data rate and clock at the user interface. Important parameters concerning the DOMSAT channel are:

- The interface on either side can handle data and clock input at the user link rate
- Bit error rates are much better than 1×10^{-5}
- Ground receipt time tagging is not planned by this link; it is expected that the processing delays between TDRSS and the user will be systematic and can be defined
- The configuration of the communications channel will be rate-sensitive and will require TBD time between rate changes.

4.5 HIGH RATE DEMULTIPLEXER

The decommutation of the data stream received on ground via the TDRSS link is performed by the HRDM. The HRDM block diagram is given in figure 4-6. The HRDM input circuit receives the serial data and clock input from the ground station.

The format generator stores up to 16 formats in programmable read-only memories (PROM's), plus two formats in RAM's. Each format consists of 768 5-bit words. Each word represents the channel address of the corresponding word in the format. One frame of the HRDM input data consists of 96 words, so one format repeats every eight frames. The two RAM's can be loaded from a ground computer.

In the Bose-Chaudhuri-Hocquenghem (BCH) decoder and data buffer, the data is buffered line-by-line and the fill identification word is decoded. Each line is then decommutated, fill words are removed, and the detected data is sent to the appropriate output channel buffer.

As shown in figure 4-7, the output buffers consist of FIFO memories capable of storing 64 16-bit words. Data is loaded in parallel into the FIFO from the BCH decoder and data buffer as it is available from the input data stream. The data words automatically bubble through the buffer from top to bottom. The data is removed from the FIFO at the appropriate rate to achieve the programmed output bit rate for every channel. Two output modes can be selected: continuous around a programmed bit rate ±1 percent, and burst mode.

In the continuous mode, the HRDM provides a smoothing of the output data stream that otherwise might have gaps caused by commutation of other channels. The clock regulator checks whether the contents of the buffer is more or less than 32 words. This information is input to a microprocessor that can adjust the clock-out frequency to within ±1 percent. In the burst mode, the clock regulation is disabled. The data is clocked out at a fixed predetermined frequency as it is decommutated. Time delays are caused only by the intermediate line-by-line buffering and the output buffer bubble-through line which is about 2 μs.

The selection of the output bit rate and of the mode for each channel is part of the format. The HRDM provides the following outputs:

- Experiment channels (16): 200 b/s up to 16 Mb/s
- HDRR (1): 2/4/8/12/16/24/32 Mb/s
- PLR (1): 1 Mb/s
- I/O units (2): 200 b/s up to 0.5 Mb/s
- GMT
- Three voice channels
- Direct access channel.

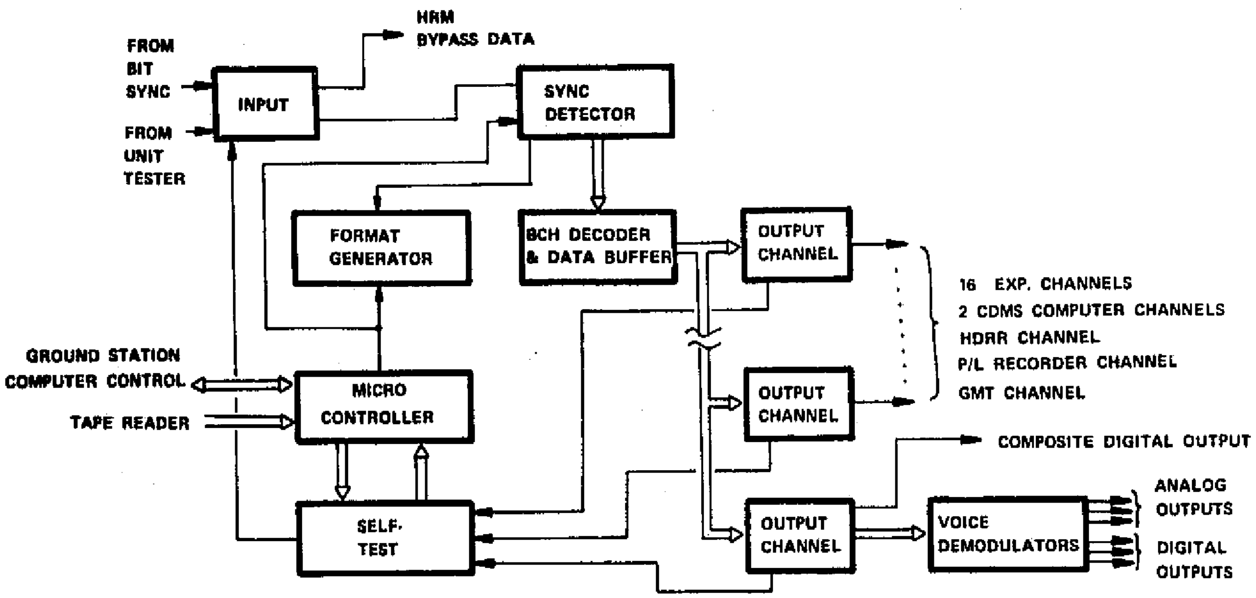


Figure 4-6 HRDM Block Diagram

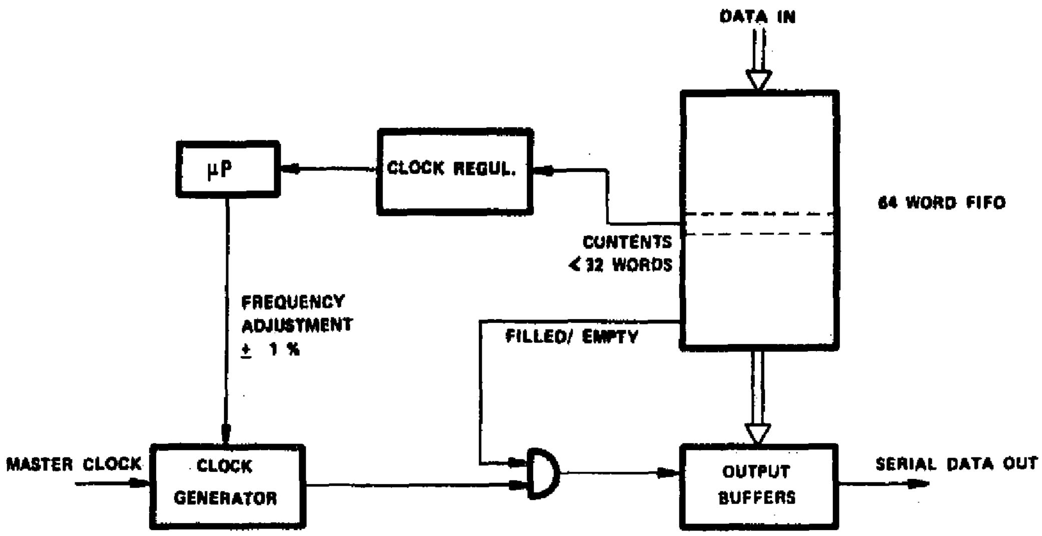


Figure 4-7 HRDM Output Channel Frequency Smoothing

Pages 4-19 through 4-21 deleted

(Refer to JSC-10013, *MCC/POCC System Specification*)

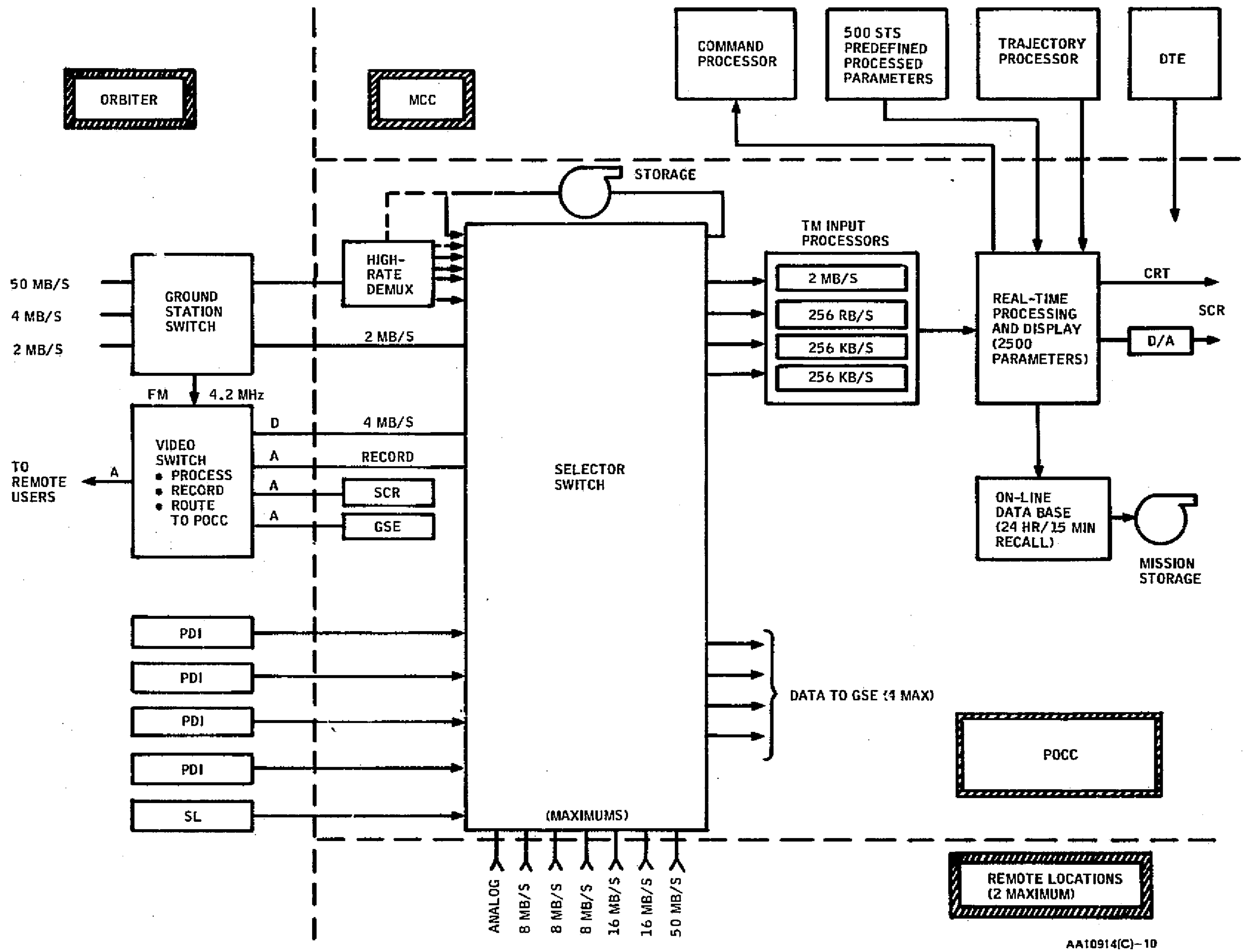


Figure 4-8 Spacelab 1 Telemetry Data Flow

ORIGINAL PAGE IS OF POOR QUALITY

J. Provide special quick-look computations on full rate and reduced rate data (optional service).

K. Provide to any user the development of software on POCC equipment, or allow the user to bring computer-compatible software for use on equipment (optional service).

L. Retain reduced rate digital data for 24 hours with a 15-minute recall.

SECTION 5

ORBITER/SPACELAB COMMAND DATA FLOW

5.1 OVERVIEW

Figure 5-1 shows a functional flow of command and verification data through the ground facilities, Orbiter, and Spacelab. This figure also shows other command flow for POCC's, Interim Upper Stage (IUS), and the free flyers. Any ground-generated command destined for the SL system(s) is sent via the Orbiter GPC. Commands are routed from the Orbiter GPC in two ways. Most commands will be routed via MDM to the subsystem/experiment computers and from there to the SL subsystems and payloads. Some commands which are required prior to activation or after de-activation will be sent via the same Orbiter MDM's directly (through RAAB) to the SL systems. Some Display Equipment Unit (DEU) equivalent commands will be required to set up the Spacelab/ORB interface.

Data to verify the commands sent to the SL can be received from two paths:

A. <u>Operational Downlink</u>

- GPC Downlist - GPC two-stage data
- OI Downlink - Experiment/subsystem computer data sent directly to PCMMU will contain SL two-stage data and may contain end-item verification data from subsystem or payload.

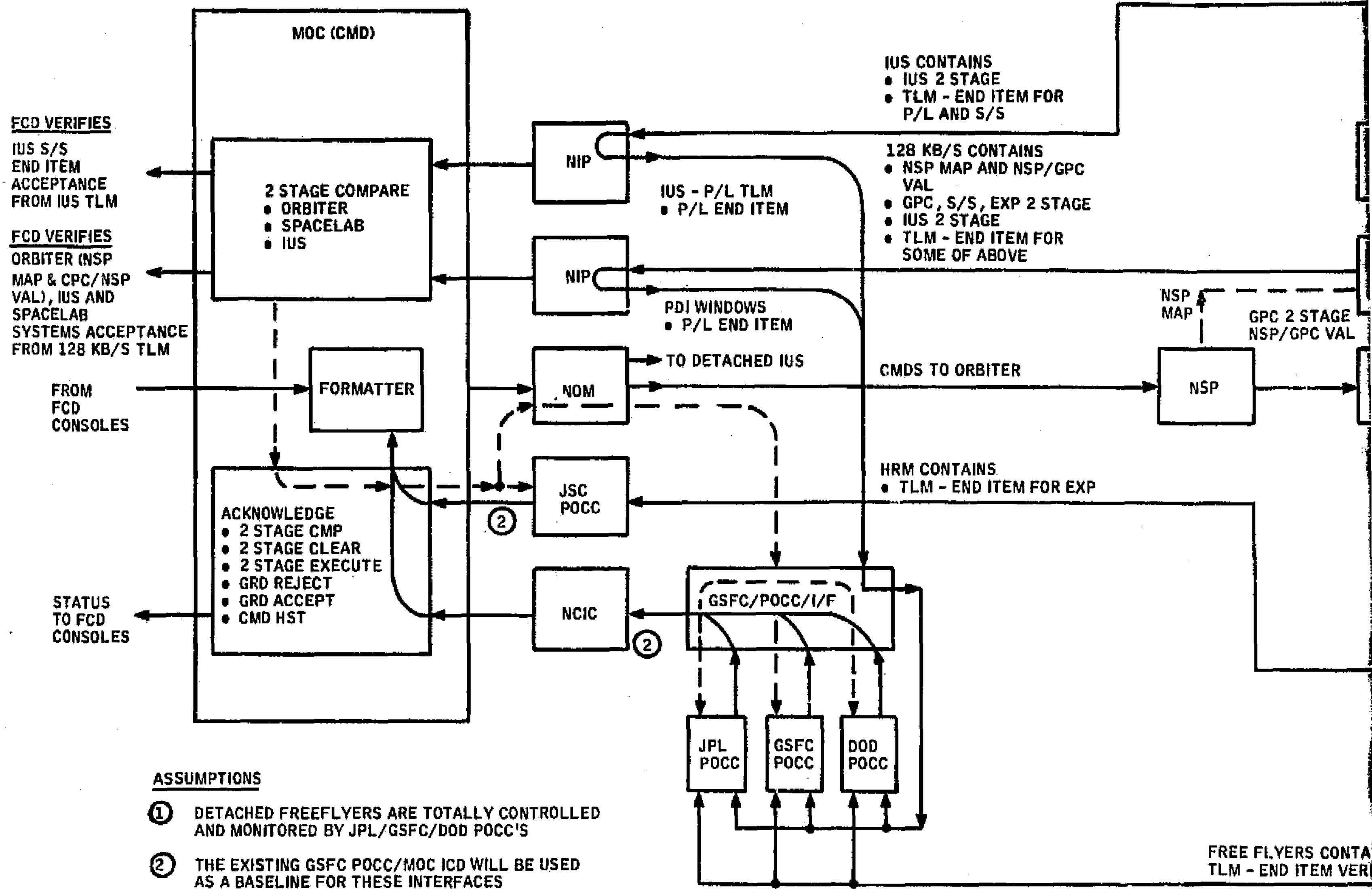
B. <u>HRM Downlink</u>

- I/O channels could contain two-stage data from the experiment computer and may contain end-item verification data from payload.
- Experiment links may contain end-item verification and Dedicated Experiment Processor (DEP) two-stage buffers.

This section does not include the latest inputs on application command functions.

FOLDOUT FRAME

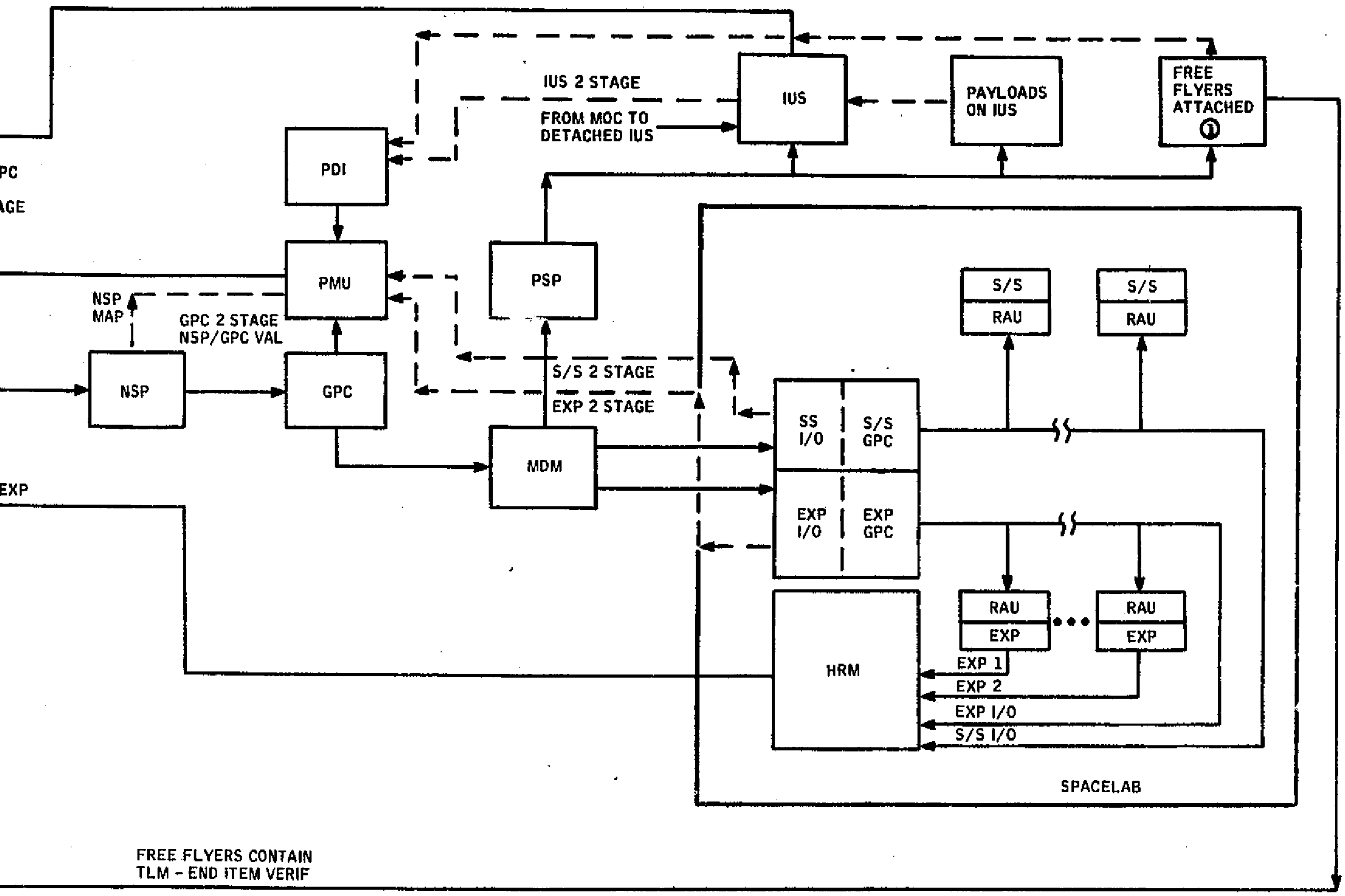
ORIGINAL PAGE IS
OF POOR QUALITY



ASSUMPTIONS

① DETACHED FREEFLYERS ARE TOTALLY CONTROLLED AND MONITORED BY JPL/GSFC/DOD POCC'S

② THE EXISTING GSFC POCC/MOC ICD WILL BE USED AS A BASELINE FOR THESE INTERFACES



COMMAND AND VERIFICATION DATA FLOW

MOC GENERATES ALL CMDS TO THE ORBITER, SPACELAB SYSTEMS AND IUS SYSTEMS AND DOES 2 STAGE COMPARE ON ALL THESE CMDS EXCEPT SINGLE STAGE RTC'S, CMD'S ARE END ITEM VERIFIED ON FCD'S DISPLAYS. MOC 2 STAGE VERIFICATION IS PERFORMED ON THE TLM FROM THE PRIME VEHICLE COMMANDED.

POCC'S GENERATES ALL CMDS TO PAYLOADS AND SENDS THEM TO THE MOC. THE MOC SENDS CAP TO POCC, REFORMATS CMDS AND TRANSMITS TO ORBITER. THE MOC VERIFIES CMDS REACHED GPC, SPACELAB COMPUTERS* AND IUS*. THE MOC SENDS 2 STAGE RESULTS TO POCC. POCC VERIFIES END ITEM ACCEPTANCE THRU TLM

*PENDING FCD REQUIREMENT

Figure 5-1 Command and Verification Data Functional Flow

5.2 EXPERIMENT COMMAND AND CONTROL

Several operational command paths are available to the experimenter for command and control of experiment operation. The ground and onboard command paths are described in figure 5-2.

5.2.1 Ground Command and Control. The ground command and data path originates from the POCC. These ground commands and data result from manual observation of experiment operation and performance, and are transferred to the experiment in the following manner.

The commands originate at the POCC, where they are checked for format and transferred to the MCC. The MCC transfers the data to the network, which relays the data to the Orbiter. The maximum rate at which the mission operations computer (MOC) can receive POCC commands is once every 12 seconds. This statement is based on the assumptions that:

- The subject commands go through the Orbiter
- The subject commands may be single or two-stage through the Orbiter.

An example timeline illustrates the two-stage mode; see figure 5-3.

The "one command every 12 seconds" assumption also assumes no errors or retransmissions. It also includes the delay time through the Orbiter and does not include any delays through the Spacelab.

5.2.2 Onboard Experiment Command and Control. Onboard the SL there are several paths to transfer commands and data to the experiments. These are described below.

A. DDS Keyboard Input Data. The ECOS will accept inputs from the SL DDS keyboards, format it for transmission, and command the EC I/O to transmit the data to the experiment via the RAU. Keyboard inputs will be routed by the ECOS, via I/O, directly to RAU output channels or stored for experiment computer applications software (ECAS) processing for later command transmission.

B. Ground Generated Data. Orbiter state vector and other corollary data will be received by GPC software and transmitted to the EC at rates up to 10 times/second via the MDM link. This data will be routed by the ECOS to the HRM for downlink, and may be routed to experiments (at up to 10 times/second) and the RAU serial PCM command channels. Application software may also use this data to sequence experiments.

C. ECOS/ECAS Generated Data. Experiment computer application software (i.e., control law, monitor, prestored sequence, etc.) may also generate commands and data for transmission to experiments as RAU ON/OFF or serial PCM commands.

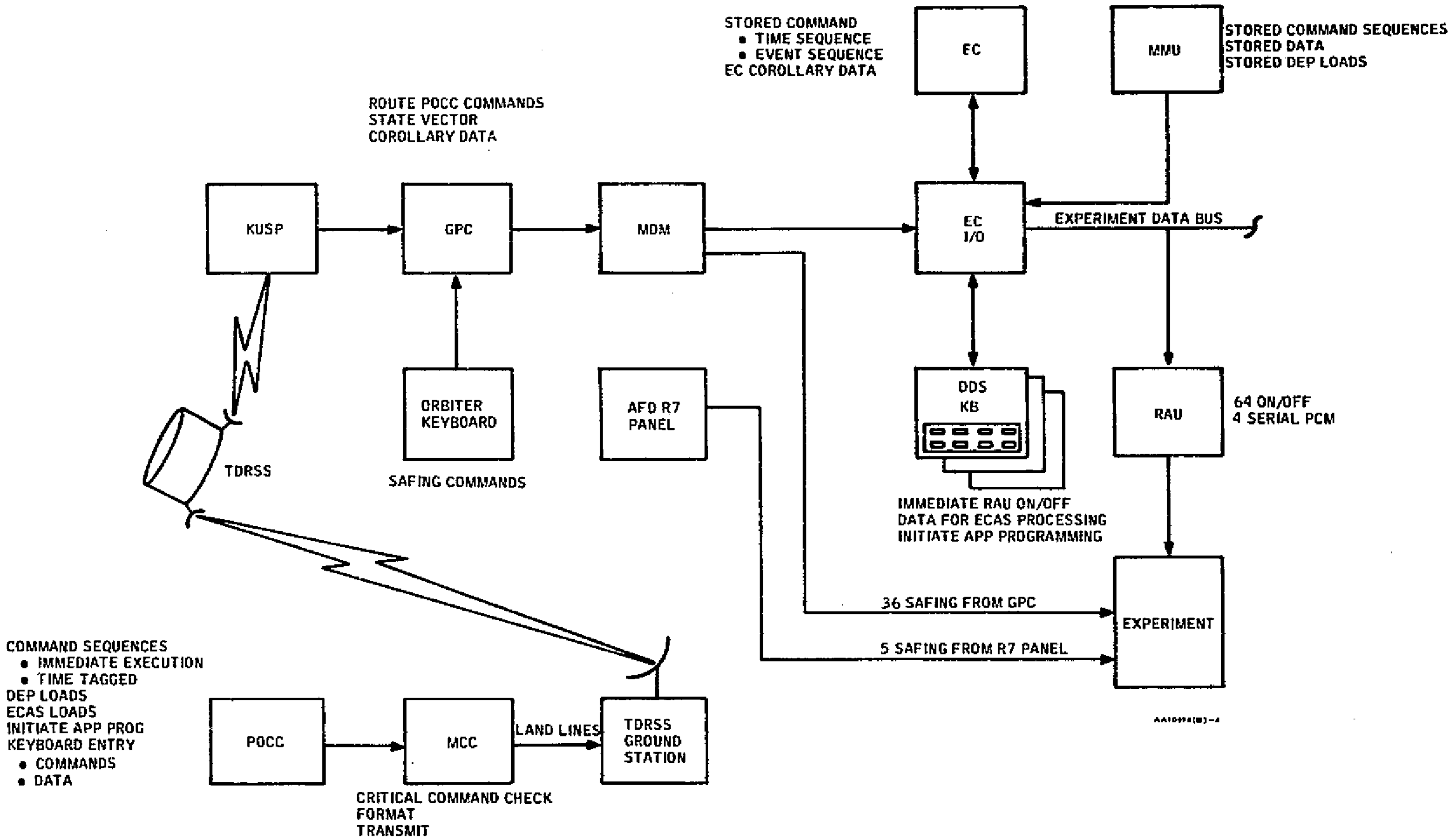


Figure 5-2 Spacelab Experiment Command Data Flow

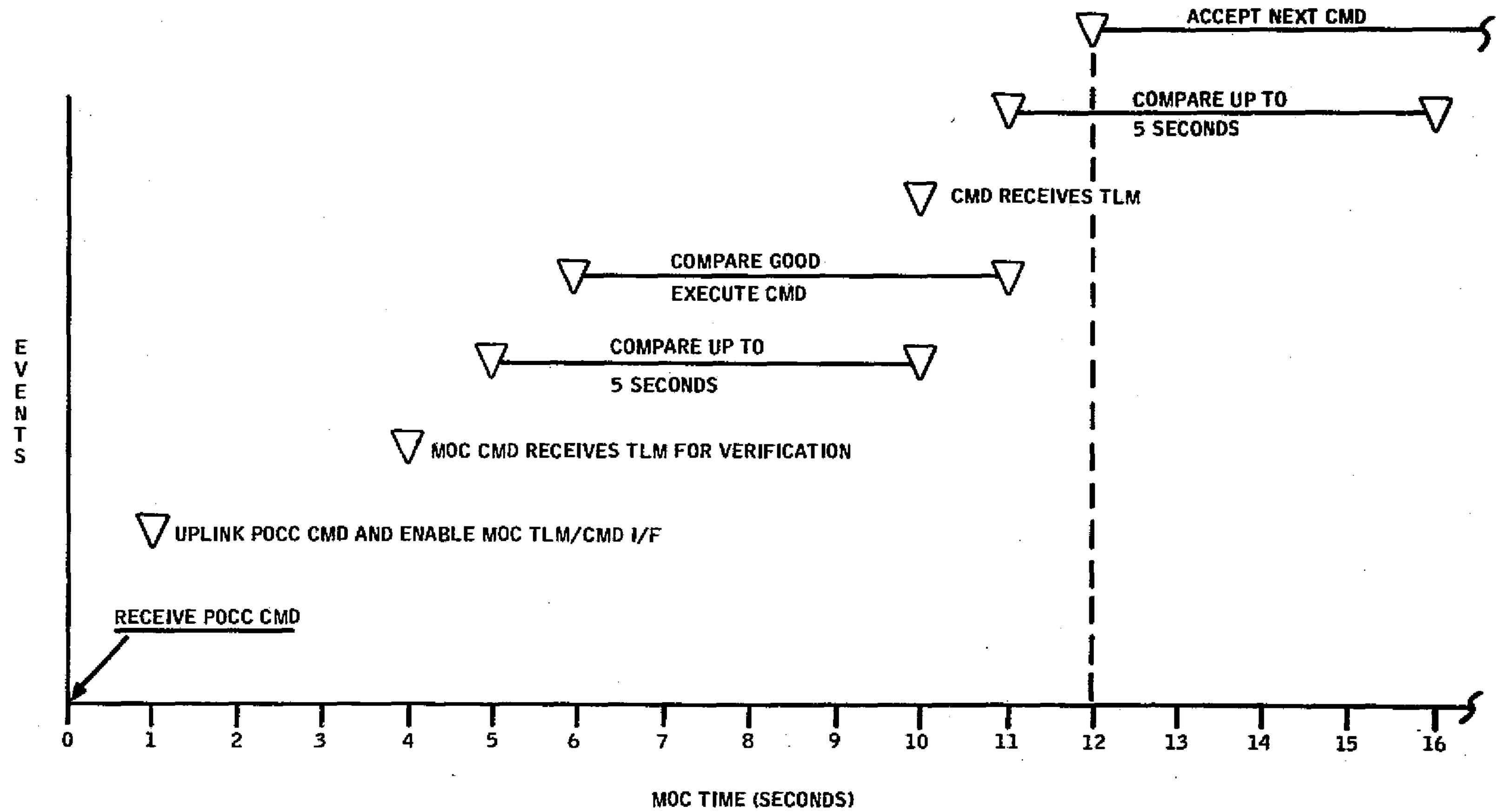


Figure 5-3 Example Timeline

D. MMU Data. Data prestored on the MMU may be retrieved under direction from ground, keyboard, or ECAS control and routed to experiments via the RAU interface.

E. Orbiter Safing System Commands. Safing commands are available to experiments as a means of safing equipment in the event of a system failure (i.e., caution and warning condition). The Orbiter will provide up to 36 safing commands for use in response to caution and warning signals. These safing commands must be manually initiated from an Orbiter display/keyboard system and will then be transmitted over an MDM discrete output directly to the experiment. In addition, switches on the AFD R7 panel are dedicated to safety-critical payload systems during launch and reentry. These switches may be hardwired from the panel to the experiments.

5.2.3 Examples of Command and Control Capabilities. The types of commands and data available for experiments and their principle sources are summarized in table 5-1. All of these commands, except for the safing commands, must come through the experiment computer and be transmitted through software to the experiment via RAU ON/OFF or serial PCM command interfaces.

The SL command and data flow can provide experimenters the capability to: activate/deactivate the experiment; control discrete experiment functions; automatically or manually sequence experiment operation; supply initialization, environmental, and operational data to experiments; load DEP memory; and modify DEP software.

TABLE 5-1

EXPERIMENT COMMAND TYPES

COMMAND/DATA TYPE	PRINCIPLE SOURCES
SINGLE FUNCTION COMMAND	
TIME SEQUENCED	POCC, EC, SLKB
EVENT SEQUENCED	EC
IMMEDIATE	POCC, SLKB
STORED COMMAND SEQUENCE	
TIME SEQUENCED	POCC, EC
EVENT SEQUENCED	EC
TPC COROLLARY DATA	GPC
EC DATA	EC
EC SOFTWARE MODIFICATION	GROUND
DEP LOAD	
TOTAL	MMU
PARTIAL	GROUND
SAFING	GPC KEYBOARD, R7 SWITCHES

5.3 SUBSYSTEM COMMAND AND CONTROL

The Spacelab computers will provide command processing for serial digital commands received via the MDM serial I/O interface (reference Spacelab/Orbiter ICD No. 2-05301) with the Orbiter GPC and Telecommand (TLC). All uplink commands will be processed by one or both of two general types of command processing -- single-stage processing and/or two-stage processing. The selection of which processing is used for any given command will be a function of the uplink command structure. Only one type of processing will be required for each MDM message.

Those commands which are required to be executed by onboard software immediately upon receipt will be handled by single-stage processing.

Commands to be processed by the two-stage processor are those commands which are buffered and downlinked via the PCMMU for review on the ground before execution. A two-stage buffer-execute command (uplink or keyboard entry) is then required to cause the command software to execute the two-stage buffer.

The single-stage processing of commands will be independent of two-stage processing so that single-stage commands may be processed while two-stage processing (review) is in progress, unless there is contention for using the same resource.

The command software will be resident in all memory configurations. The design approach to command software will be such that no design/code change is required to configure for end-item dependent applications needs.

The command functions requiring command processor support are defined in tables 5-2 and 5-2A. Table 5-3 contains the Spacelab RAU Command List.

5.3.1 <u>Single-State Processing</u>. Execution of single-stage process commands will be initiated immediately upon receipt of the uplink command.

TABLE 5-2

S/L COMMAND FUNCTIONS

RECORD ID (HEX CODE)	COMMAND
20	SSPC Load
21	Issue Discrete
22	Issue Multiple Discretes
23	Write Serial with Fixed Data
24	Write Serial with Variable Data
25	HRM Format Load via MMU
26	HRM Format Load via MDM
27	Spare
28	Start Task
29	Load Memory Configuration from MMU
2A	Cancel
2B	Terminate
2C	Write Core Memory
2D	Write Core Memory Scatter
2E	Dump Core Memory
2F	Dump MMU Block
30	Load Memory Configuration from MDM
31	Checkpoint Initialize
32	Checkpoint Retrieval
33	Change Monitor Data
34	Clear SSPC Buffer
35	Clear Two Stage Buffer
36	Execute Two Stage Buffer
37	MET Initialize
38	Set CDT Active/Inactive Bit
39	Switch to MTU

TABLE 5-2 (CONT'D)

RECORD ID (HEX CODE)	COMMAND
3A	Declare DPA End Item OP/NOP
3B	Orbiter Position Vector (GTOD)
3C	Orbiter Attitude Vector (GTOD)
3D	Orbiter Position/Attitude Vector
3E	Read MMU
3F	Write MMU
40	Update RTC GMT

TABLE 5-2A

S/L APPLICATION COMMAND FUNCTIONS

RECORD ID (HEX CODE)	APPLICATION PROGRAM COMMANDS
60	Receive Memory Load

TABLE 5-3 (CONT'D)

Subsystem: EPDS 2

REFERENCE TO COMMAND IDENT. NUMBER	COMMAND NAME	CDM SOURCE MDM	RAU	AFD SW	S/L SW	REMARKS
S01K0291	LIGHTS 1, 3, 11 ON				X	Manual circuit
S01K0292	LIGHTS 1, 3, 11 OFF				X	breakers only
S01K0293	LIGHTS 3, 4, 9, 10 ON				X	
S01K0294	LIGHTS 3, 4, 9, 10 OFF				X	
S01K0295	LIGHTS 2, 5, 7, 12 ON				X	
S01K0296	LIGHTS 2, 5, 7, 12 OFF				X	
S01K0401	EPDB 1 ALL DC+AC OUTPUTS ON	B				BU of cmd's
S01K0402	EPDB 1 ALL DC+AC OUTPUTS OFF	B				403 to 414
S01K0403	EPDB 1 DC11 OUTPUT ON		P			
S01K0404	EPDB 1 DC11 OUTPUT OFF		P			
S01K0405	EPDB 1 DC12 OUTPUT ON		P			
S01K0406	EPDB 1 DC12 OUTPUT OFF		P			
S01K0407	EPDB 1 DC13+14 OUTPUT ON		P			
S01K0408	EPDB 1 DC13+14 OUTPUT OFF		P			
S01K0409	EPDB 1 AC11 OUTPUT ON		P			
S01K0410	EPDB 1 AC11 OUTPUT OFF		P			
S01K0411	EPDB 1 AC12 OUTPUT ON		P			
S01K0412	EPDB 1 AC12 OUTPUT OFF		P			
S01K0413	EPDB 1 AC13+14 OUTPUT ON		P			
S01K0414	EPDB 1 AC13+14 OUTPUT OFF		P			
S01K0421	EPDB 2 ALL DC+AC OUTPUTS ON	B				BU of cmd's
S01K0422	EPDB 2 ALL DC+AC OUTPUTS OFF	B				423 to 434
S01K0423	EPDB 2 DC21 OUTPUT ON		P			
S01K0424	EPDB 2 DC21 OUTPUT OFF		P			
S01K0425	EPDB 2 DC22 OUTPUT ON		P			
S01K0426	EPDB 2 DC22 OUTPUT OFF		P			
S01K0427	EPDB 2 DC23+24 OUTPUT ON		P			
S01K0428	EPDB 2 DC23+24 OUTPUT OFF		P			
S01K0429	EPDB 2 AC21 OUTPUT ON		P			
S01K0430	EPDB 2 AC21 OUTPUT OFF		P			
S01K0431	EPDB 2 AC22 OUTPUT ON		P			
S01K0432	EPDB 2 AC22 OUTPUT OFF		P			
S01K0433	EPDB 2 AC23+24 OUTPUT ON		P			
S01K0434	EPDB 2 AC23+24 OUTPUT OFF		P			
S01K0441	EPDB 3 ALL DC+AC OUTPUTS ON	B				BU of cmd's
S01K0442	EPDB 3 ALL DC+AC OUTPUTS OFF	B				443 to 454
S01K0443	EPDB 3 DC31 OUTPUT ON		P			
S01K0444	EPDB 3 DC31 OUTPUT OFF		P			
S01K0445	EPDB 3 DC32 OUTPUT ON		P			
S01K0446	EPDB 3 DC32 OUTPUT OFF		P			
S01K0447	EPDB 3 DC33+34 OUTPUT ON		P			
S01K0448	EPDB 3 DC33+34 OUTPUT OFF		P			

TABLE 5-3 (CONT'D)

Subsystem: EPDS 2						
REFERENCE TO COMMAND IDENT. NUMBER	COMMAND NAME	CDM SOURCE				REMARKS
		MDM	RAU	AFD SW	S/L SW	
S01K0291	LIGHTS 1, 8, 11 ON				X	Manual circuit breakers only
S01K0292	LIGHTS 1, 3, 11 OFF				X	
S01K0293	LIGHTS 3, 4, 9, 10 ON				X	
S01K0294	LIGHTS 3, 4, 9, 10 OFF				X	
S01K0295	LIGHTS 2, 5, 7, 12 ON				X	
S01K0296	LIGHTS 2, 5, 7, 12 OFF				X	
S01K0401	EPDB 1 ALL DC+AC OUTPUTS ON	B				BU of cmd's 403 to 414
S01K0402	EPDB 1 ALL DC+AC OUTPUTS OFF	B				
S01K0403	EPDB 1 DC11 OUTPUT ON		P			
S01K0404	EPDB 1 DC11 OUTPUT OFF		P			
S01K0405	EPDB 1 DC12 OUTPUT ON		P			
S01K0406	EPDB 1 DC12 OUTPUT OFF		P			
S01K0407	EPDB 1 DC13+14 OUTPUT ON		P			
S01K0408	EPDB 1 DC13-14 OUTPUT OFF		P			
S01K0409	EPDB 1 AC11 OUTPUT ON		P			
S01K0410	EPDB 1 AC11 OUTPUT OFF		P			
S01K0411	EPDB 1 AC12 OUTPUT ON		P			
S01K0412	EPDB 1 AC12 OUTPUT OFF		P			
S01K0413	EPDB 1 AC13-14 OUTPUT ON		P			
S01K0414	EPDB 1 AC13-14 OUTPUT OFF		P			
S01K0421	EPDB 2 ALL DC+AC OUTPUTS ON	B				BU of cmd's 423 to 434
S01K0422	EPDB 2 ALL DC+AC OUTPUTS OFF	B				
S01K0423	EPDB 2 DC21 OUTPUT ON		P			
S01K0424	EPDB 2 DC21 OUTPUT OFF		P			
S01K0425	EPDB 2 DC22 OUTPUT ON		P			
S01K0426	EPDB 2 DC22 OUTPUT OFF		P			
S01K0427	EPDB 2 DC23+24 OUTPUT ON		P			
S01K0428	EPDB 2 DC23-24 OUTPUT OFF		P			
S01K0429	EPDB 2 AC21 OUTPUT ON		P			
S01K0430	EPDB 2 AC21 OUTPUT OFF		P			
S01K0431	EPDB 2 AC22 OUTPUT ON		P			
S01K0432	EPDB 2 AC22 OUTPUT OFF		P			
S01K0433	EPDB 2 AC23+24 OUTPUT ON		P			
S01K0434	EPDB 2 AC23+24 OUTPUT OFF		P			
S01K0441	EPDB 3 ALL DC+AC OUTPUTS ON	B				BU of cmd's 443 to 454
S01K0442	EPDB 3 ALL DC+AC OUTPUTS OFF	B				
S01K0443	EPDB 3 DC31 OUTPUT ON		P			
S01K0444	EPDB 3 DC31 OUTPUT OFF		P			
S01K0445	EPDB 3 DC32 OUTPUT ON		P			
S01K0446	EPDB 3 DC32 OUTPUT OFF		P			
S01K0447	EPDB 3 DC33+34 OUTPUT ON		P			
S01K0448	EPDB 3 DC33+34 OUTPUT OFF		P			

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 5-3 (CONT'D)

Subsystem: EPDS 3

REFERENCE TO COMMAND IDENT. NUMBER	COMMAND NAME	CDM SOURCE MDM	RAU	AFD SW	S/L SW	REMARKS
S01K0449	EPDB 3 AC31 OUTPUT ON		P			
S01K0450	EPDB 3 AC31 OUTPUT OFF		P			
S01K0451	EPDB 3 AC32 OUTPUT ON		P			
S01K0452	EPDB 3 AC32 OUTPUT OFF		P			
S01K0453	EPDB 3 AC33+34 OUTPUT ON		P			
S01K0454	EPDB 3 AC33+34 OUTPUT OFF		P			
S01K0461	EPDB 4 ALL DC+AC OUTPUTS ON	B				BU of cmd's 463 to 474
S01K0462	EPDB 4 ALL DC+AC OUTPUTS OFF	B				
S01K0463	EPDB 4 DC41 OUTPUT ON		P			
S01K0464	EPDB 4 DC41 OUTPUT OFF		P			
S01K0465	EPDB 4 DC42 OUTPUT ON		P			
S01K0466	EPDB 4 DC42 OUTPUT OFF		P			
S01K0467	EPDB 4 DC43+44 OUTPUT ON		P			
S01K0468	EPDB 4 DC43+44 OUTPUT OFF		P			
S01K0469	EPDB 4 AC41 OUTPUT ON		P			
S01K0470	EPDB 4 AC41 OUTPUT OFF		P			
S01K0471	EPDB 4 AC42 OUTPUT ON		P			
S01K0472	EPDB 4 AC42 OUTPUT OFF		P			
S01K0473	EPDB 4 AC43+44 OUTPUT ON		P			
S01K0474	EPDB 4 AC43+44 OUTPUT OFF		P			
S01K0481	EPDB 5 ALL DC+AC OUTPUT ON	B				BU of cmd's 483 to 494
S01K0482	EPDB 5 ALL DC+AC OUTPUT OFF	B				
S01K0483	EPDB 5 DC51 OUTPUT ON		P			
S01K0484	EPDB 5 DC51 OUTPUT OFF		P			
S01K0485	EPDB 5 DC52 OUTPUT ON		P			
S01K0486	EPDB 5 DC52 OUTPUT OFF		P			
S01K0487	EPDB 5 DC53+54 OUTPUT ON		P			
S01K0488	EPDB 5 DC53+54 OUTPUT OFF		P			
S01K0489	EPDB 5 AC51 OUTPUT ON		P			
S01K0490	EPDB 5 AC51 OUTPUT OFF		P			
S01K0491	EPDB 5 AC52 OUTPUT ON		P			
S01K0492	EPDB 5 AC52 OUTPUT OFF		P			
S01K0493	EPDB 5 AC53+54 OUTPUT ON		P			
S01K0494	EPDB 5 AC53+54 OUTPUT OFF		P			

TABLE 5-3 (CONT'D)

Subsystem: COMS I

REFERENCE TO COMMAND IDENT. NUMBER	COMMAND NAME	COM SOURCE				REMARKS
		MDM	RAU	AFD SW	S/L SW	
S03K0101	SS-COMP PWR ON/SS-DMA TO SS COMP	P				
S02K0102	SS-COMP PWR OFF/AUTO RESTART OFF	P				(1)
S03K0105	SS-COMP AUTO RESTART ON	P				
S03K0106	SS-COMP LOAD VIA MMU	P				
S02K0107	SS-COMP LOAD VIA MDM	P				
S03K0131	BU-COMP PWR ON/SS DMA TO BU COMP	P(2)				BU Equipment
S03K0133	BU-COMP PWR ON/EXP DMA TO BU COMP		P(2)			BU Equipment
S03K0132	BU-COMP PWR OFF/AUTO RESTART OFF	P(2)				(1) BU Equipment
S03K0135	BU-COMP AUTO RESTART ON	P(2)	P(2)			BU Equipment
S03K0136	BU-COMP LOAD VIA MMU	P(2)	P(2)			BU Equipment
S03K0137	BU-COMP LOAD VIA MDM	P(2)	P(2)			
S03K0134	BU-COMP PWN OFF/AUTO RESTAUR OFF		P(2)			
S03K0161	EXP-COMP PWR ON/EXP DMA TO EXP COMP		P			
S03K0162	EXP-COMP PWR OFF/AUTO RESTART OFF		P			(1)
S03K0165	EXP-COMP AUTO RESTART ON		P			
S03K0166	EXP-COMP LOAD VIA MMU		P			
S03K0167	EXP-COMP LOAD VIA MDM		P			
S03K0191	MMU PWR ON	P(2)	P(2)			
S03K0192	MMU PWR OFF	P(2)	P(2)			(1)
S03K0201	SS-I/O PWR A ON/	P				
S03K0202	SS-I/O PWR B ON	P				BU Circuit
S02K0203	SS-I/O PWR A+B OFF	P				(1)
S03K0204	SS ALL COUPLERS A ON/DMA TO SS-COUP	P				
S03K0211	SS MDM COUPLER B ON	P				BU Circuit
S03K0212	SS PCMMU COUPLER B ON	P				BU Circuit
S03K0213	SS MMU COUPLER B ON	P				BU Circuit
S03K0214	SS RAU COUPLER B ON	P				BU Circuit
S03K0215	SS DDU/KB COUPLER B ON	P				BU Circuit
S03K0216	SS TIME COUPLER OFF	P				
S03K0251	EXP-I/O PWR A ON/DMA TO EXP COMP		P			
S03K0252	EXP-I/O PWR B ON		P			BU Circuit
S03K0253	EXP-I/O PWR A+B OFF		P			(1)
S03K0254	EXP-I/O ALL COUPLERS A ON/DMA TO EXP-COMP		P			
S03K0261	EXP-I/O MDM COUPLER B ON		P			BU Circuit
S03K0262	EXP-I/O PCMMU COUPLER B ON		P			BU Circuit
S03K0263	EXP-I/O MMU COUPLER B ON		P			BU Circuit
S03K0264	EXP-I/O RAU COUPLER B ON		P			BU Circuit
S03K0265	EXP-I/O DDU/KB COUPLER B ON		P			BU Circuit
S03K0266	EXP-I/O TIME COUPLER OFF		P			

TABLE 5-3 (CONT'D)

ORIGINAL PAGE IS OF POOR QUALITY

Subsystem: CDMS 2

REFERENCE TO COMMAND IDENT. NUMBER	COMMAND NAME	CDM SOURCE				REMARKS
		MDM	RAU	AFD SW	S/L SW	
S03K0301	ALL SS-RAU PWR ON	P				
S03K0302	ALL SS-RAU PWR OFF	P				(1)
S03K0311	SS-RAU A PWR ON	X				X Cmd's used to
S03K0316	SS-RAU B PWR ON	X				isolate failed
S03K0321	SS-RAU C PWR ON	X				RAU and for test
S03K0326	SS-RAU D PWR ON	X				and C/O purpose.
S03K0331	SS-RAU E PWR ON	X				May be used as BU
S03K0336	SS-RAU F PWR ON	X				cmd's of S03K0301
S03K0341	SS-RAU G PWR ON	X				
S03K0346	SS-RAU H PWR ON					
S03K0401	ALL EXP-RAU PWR ON	B				BU cmd for individual EXP-RAU on cmd
-	ALL EXP-RAU PWR OFF	-				(1)
S03K0406	EXP RAU ( ) PWR on		P			(3)
to						
S03K0597	EXP RAU ( ) PWR OFF		P			(3)
S03K0731	HRDR PWR ON		P			
S03K0732	HRDR PWR OFF		P			
S03K0733	HRDR STOP		P			
S03K0741	HRDR RECORD		P			
S03K0742	REPLAY		P			
S03K0744	HRDR FAST FORWARD		P			
S03K0745	HRDR FAST REWIND		P			
S03K0751	HRDR RATE 1-2 MBPS		P			
S03K0752	HRDR RATE 2-4 MBPS		P			
S03K0753	HRDR RATE 4-8 MBPS		P			
S03K0754	HRDR RATE 8-16 MBPS		P			
S03K0755	HRDR RATE 16-32		P			
S03K0761	HRDR SELF TEST		P			
S03K0001	CDMS MASTER PWR OFF	B				(4)
S03K0801	HRM PWR ON		P			
S03K0802	HRM PWR OFF		P			

NOTE:

(1) BU cmd is provided by CDMS MASTER PWR OFF S03K0001

(2) MDM cmd's are used when the BU comp is used as BU of SS-comp RAU cmd's are used when the BU comp is used as BU of Exp-comp

(3) ON/OFF cmd's are provided at each EXP-RAU location from the nearest SS-RAU

(4) BU cmd for:
S03K0102
S03K0132
S03K0162
S03K0192
S03K0203
S03K0253
S03K0302
All EXP-RAU's PWR OFF

TABLE 5-3 (CONT'D)

Subsystem: EC/LS I

REFERENCE TO COMMAND IDENT. NUMBER	COMMAND NAME	CDM SOURCE				REMARKS
		MDM	RAU	AFD SW	S/L SW	
S02K0111	N_2-VALVE 1301-1 OPEN		P			
S02K0112	N_2-VALVE 1301-1 CLOSE		P			
S02K0113	N_2-VALVE 1301-2 OPEN		P			BU Equipment
S02K0114	N_2-VALVE 1301-2 CLOSE		P			BU Equipment
S02K0131	O_2-SHUT OFF VLV 1223 OPEN		P			
S02K0132	O_2-SHUT OFF VLV 1223 CLOSE		P	X		X Emergency Cmd
S02K0151	N_2-CTRL VALVE 1401-1 OPEN		P			
S02K0152	N_2-CTRL VALVE 1401-1 CLOSE		P			
S02K0153	N_2-CTRL VALVE 1401-2 OPEN		P			BU Equipment
S02K0154	N_2-CTRL VALVE 1401-2 CLOSE		P			BU Equipment
S02K0211	DEPRESS VALVE 1604 ARM			X		X Emergency Cmd
S02K0212	DEPRESS VALVE 1604 OPEN			X		X Emergency Cmd
S02K0213	DEPRESS VALVE 1604 CLOSE			X		X Emergency Cmd
S02K0231	PRESS. RELIEF VLV 1601-1 OPEN			P		
S02K0232	PRESS. RELIEF VLV 1601-1 CLOSE			P		
S02K0233	PRESS. RELIEF VLV 1601-2 OPEN			P		
S02K0234	PRESS. RELIEF VLV 1601-2 CLOSE			P		BU Equipment
S02K0301	CABIN FAN 2104-1 ON	P				
S02K0303	CABIN FAN 2104-2 ON	P				
S02K0305	CABIN FAN 2104-1/2 OFF	P				BU Equipment (1)
S02K0321	TEMP CONTROLLER 2301-1 ON		P			
S02K0322	TEMP CONTROLLER 2303-1 OFF		P			
S02K0341	TEMP CONTROLLER 2301-2 ON		P			BU Equipment
S02K0342	TEMP CONTROLLER 2301-2 OFF		P			BU Equipment
S02K0325	TEMP. SELECT 2309-1				X	X Analog Setting
S02K0345	TEMP. SELECT 2309-2				X	BU Equipment
S02K0401	ROTARY SEPARATOR 2403-1 ON		P			
S02K0402	ROTARY SEPARATOR 2403-1 OFF		P			(1)
S02K0411	ROTARY SEPARATOR 2403-2 ON		P			BU Equipment
S02K0412	ROTARY SEPARATOR 2403-2 OFF		P			(1) BU Equipment
S02K0431	CONDENS. DUMP VLV 2601 OPEN 1				P	
S02K0432	CONDENS. DUMP VLV 2601 OPEN 2				B	
S02K0433	CONDENS. DUMP VLV 2601 CLOSE 1		B		P	
S02K0434	CONDENS. DUMP VLV 2601 CLOSE 2		B		B	
S02K0441	NOZZLE TEMP. CONTR. 2606-1 ON				P	
S02K0442	NOZZLE TEMP. CONTR. 2601-1 OFF				P	
S02K0443	NOZZLE TEMP. CONTR. 2601-2 ON				P	
S02K0444	NOZZLE TEMP. CONTR. 2601-2 OFF				P	

TABLE 5-3 (CONT'D)

ORIGINAL PAGE IS OF POOR QUALITY

Subsystem: EC/LS 2

REFERENCE TO COMMAND IDENT. NUMBER	COMMAND NAME	CDM SOURCE				REMARKS
		MDM	RAU	AFD SW	S/L SW	
S02K0501	AVIONICS FAN 1 LOW SPEED ON	P		B		(1)
S02K0502	AVIONICS FAN 1 HIGH SPEED ON		P			BU Equipment
S02K0503	AVIONICS FAN 1 OFF		B	B		(1) BU Equipment
S02K0504	AVIONICS FAN 2 LOW SPEED ON	P		B		
S02K0505	AVIONICS FAN 2 HIGH SPEED ON		P			
S02K0506	AVIONICS FAN 2 OFF		B	B		
S02K0507	AVIONICS FAN 1+2 OFF	P				
S02K0011	FIRE&SMOKE SENSOR 1 INHIBIT			X		
S02K0012	FIRE&SMOKE SENSOR 2 INHIBIT			X		
S02K0013	FIRE&SMOKE SENSOR 3 INHIBIT			X		
S02K0014	FIRE&SMOKE SENSOR 4 INHIBIT			X		
S02K0015	FIRE&SMOKE SENSOR 5 INHIBIT			X		
S02K0016	FIRE&SMOKE SENSOR 6 INHIBIT			X		
S02K0001	FIRE&SMOKE SENSORS TEST			P		
S02K0002	FIRE&SMOKE SENSORS RESET			P		
S02K0020	FIRE SUPPRESSION SYSTEM ARM			X		X Emergency Cmd's
S02K0030	FIRE SUPPRESSION SYSTEM ARM				X	
S02K0021	SUPPRESSANT DISCHARGE LEFT			X		
S02K0031	SUPPRESSANT DISCHARGE LEFT				X	
S02K0022	SUPPRESSANT DISCHARGE CABIN			X		
S02K0032	SUPPRESSANT DISCHARGE CABIN				X	
S02K0023	SUPPRESSANT DISCHARGE RIGHT			X		
S02K0033	SUPPRESSANT DISCHARGE RIGHT				X	
S02K0051	ECLS MASTER PWR OFF	B				(2)

NOTE:

(1) BU cmd is provided by ECS MASTER POWER OFF cmd S02K0051

(2) BU cmd for
S02K0305
S02K0402
S02K0412
S02K0502
S02K0504
S04K0123
S04K0223

TABLE 5-3 (CONT'D)

Subsystem: EC/TC						
REFERENCE TO COMMAND IDENT. NUMBER	COMMAND NAME	CDM SOURCE				REMARKS
		MDM	RAU	AFD SW	S/L SW	
S04K0121	WATER PUMP 1 PWR ON	P		B		
S04K0122	WATER PUMP 1 PWR OFF			B		BU Equipment
S04K0123	WATER PUMP 2 PWR ON	P		B		(1)
S04K0124	WATER PUMP 2 PWR OFF			B		
S04K0125	WATER PUMS 1&2 PWR OFF	P				
S04K0221	FREON PUMP 1 PWR ON	P				
S04K0223	FREON PUMP 2 PWR ON	P				BU Equipment
S04K0225	FREON PUMPS 1&2 PWR OFF	P				(1)
S04K0321	WATER LINE HEATERS ON				P	
S04K0322	WATER LINE HEATERS AUTO				P	
S04K0323	WATER LINE HEATERS OFF				P	Note: (1) BU cdm is provided by ECS MASTER PWR OFF S02K0051

5.3.2 Two-Stage Processing*. Two stage processing is required to review each MDM message (all user records in one MDM transmission, with a maximum of 31 16-bit words) prior to execution. The Subsystem Computer (SSC) and/or the Experiment Computer (EC) will store the MDM message in the two-stage buffer and then route this data to the PCMMU. A two-stage buffer execute command will then be required to transfer the contents of the buffer to the appropriate user specified by the RIW (see para. 5.5). Execution of the two-stage buffer may also be accomplished by the receipt of another MDM message with the same RIW (implied execute) as the message currently in the two-stage buffer. In addition to transferring the contents to the user, the buffer will be cleared and made available for another MDM message. The buffer will also be cleared upon SSC and/or EC initialization. If, during verification, the contents of the two-stage buffer are found to be in error, a buffer clear command will be issued from the ground to clear the buffer. The two-stage buffer will be sized to accommodate one MDM message as defined above.

The command software will check the fields in the RIW of the MDM message. If the RIW contains illegal codes, the MDM message will not be processed further. Illegal codes and the resulting error processing will be defined by the software developer. All error condition codes detected will be routed to the PCMMU.

Once a MDM message is in the two-stage buffer, no other two-stage MDM message will be entered into the buffer unless it has the same RIW as the MDM message currently in the buffer. If an attempt is made to load another MDM message without the same RIW into the buffer, the software will reject the latter message and set the appropriate error condition code for downlink. A buffer clear (buffer value goes to all zeros) or execute will release the two-stage buffer for receipt of an MDM message with a different RIW.

5.3.3 Spacelab Stored Program Commands (SSPC). There is a requirement that the subsystems computer accept commands with an associated GMT tag for each command. These commands will be transferred via single-stage or two-stage processing into the SSPC buffer for storage until time of execution. In addition, SSPC's will be entered into the SSPC buffer via keyboard entries. The SSPC buffer will order SSPC's by time. The SSPC buffer content will be provided to the PCMMU for downlink, and to the crew for display. When the current time matches the GMT time tag of a given SSPC in the buffer, the command will be executed.

The SSPC buffer will be sized to contain a maximum of 10 commands with their associated time words. Once the execution time tag has expired for a given command, the space will be available for subsequent SSPC storage.

*As it presently stands, a command could be treated as a two-stage in the GPC and then as a two-stage in the Spacelab computers (tandem two-stage).

The capability will exist to clear the entire SSPC buffer via an SSPC buffer clear command to be sent from the ground or the Spacelab keyboard, or to clear individual SSPC's via keyboard entry. It shall also be cleared upon SSC initialization.

If an attempt is made to enter an SSPC into the full SSPC buffer, it will be rejected and an error message generated for the PCMMU and crew display.

5.3.4 Ground Uplink to MMU. A mass memory unit (MMU) update will be accomplished by uplinking a mass memory read command. Upon execution of a mass memory read command, the SSC will cause the specified block to be transferred from the mass memory to the mass memory buffer in the SSC. The SSC main memory write function will then be used to update up to 30 words at a time of the mass memory buffer in main memory. Upon completion of the update, a mass memory write command will be uplinked. Upon execution of this command, the SSC will cause the block of updated data to be transferred to the specified block on mass memory. An update to a mass memory block may consist of from 1 to 512 words, up to 30 words at a time. A complete mass memory block input can be accomplished as discussed above by omitting the mass memory read function. The format of the update will be consistent with the stored format; i.e., all MMU stored programs will be in absolute memory image (AMI) format.

Proper sumchecks in the mass memory must be uplinked as data. The SCOS will not automatically compute the proper checksum. The checksums will be provided by the user as a data input, except that SCOS will automatically calculate checksum value for user files only.

5.4 SPACELAB ACTIVATION AND ON-ORBIT OPERATIONS

Spacelab activation will be performed by the Orbiter crew using primarily the systems management/payload GPC. This activation program will contain all the necessary primary and backup discrete MDM and RAU subsystem commands required to activate Spacelab.

In addition to the commands, the activation program display on the CRT will contain the necessary Spacelab systems data to verify proper subsystem response to each command. The sequencing will be in response to Orbiter GPC keyboard inputs by the crewman. An input is required for each command output; i.e., there is no automatic sequencing. Both the commands and response of the activation sequence will be continuously updated on the Orbiter CRT for the crewman. All response data will be displayed in the most meaningful fashion; any out-of-limits conditions will be detected and annunciated by the Orbiter FDA software.

If any out-of-limits condition is detected, the crewman will procedurally determine the extent of the problem and determine the proper course of action to correct it. No SSC software is required to perform fault localization. All the commands to backup system components (e.g., redundant fan or pump) will be available in the activation sequence, and can be used to correct any problem.

The subsystem computer I/O unit, SSC, MMU, and subsystem RAU's will be activated via MDM discrete commands and serial MDM commands for SSC software control using the Orbiter CRT keyboard.

The experiment computer system, although not directly connected to the Orbiter via MDM discrete channels, will be activated via the serial MDM channel and the SSC using the Orbiter CRT keyboard; this is identical to the SSC activation.

The high rate data assembly (HRDA) system will be activated from the Orbiter CRT keyboard or the MCC. Full on-orbit control and monitoring by the HRDA system is primarily an MCC function, with backup through the Orbiter CRT keyboard. Only status information and configuration control will be necessary from a Spacelab DDU keyboard.

The airlock will be activated, monitored, and controlled primarily via the airlock hardware display and control. Any additional status information will be provided via SL DDU.

The instrument pointing system will be activated, monitored, and controlled primarily with the Spacelab DDU keyboard system.

As a backup to the primary Spacelab C&W parameter processing in the Orbiter, independent C&W processing will be performed in the subsystem computer. All associated controls and display functions are performed via the Spacelab DDU keyboard.

To satisfy the above operations concept, the Orbiter will provide software to activate, monitor, and control the basic Spacelab subsystems during its entire flight phase. This software consists primarily of command and display generation, limit sensing, and engineering-unit conversion of Spacelab parameters.

5.5 SPACELAB COMMAND FORMATS

The following paragraphs list each S/L command type, a description of the command function, and its format.

The uplink command structure will use a minimum number of 16-bit words. Specifically, commands for RAU discretes, HRM discrete control functions, and HRM configuration changes will contain one 16-bit data word plus the command header word (CHW) and record identification word (RIW) words. It will also be possible to load the HRM from the ground by uplinking the entire 18 consecutive 16-bit words of data necessary for HRM configuration/format changes. The 16-bit data word will contain an identification number which will be the same for each end-item/function from mission to mission. In addition, the computer will automatically perform a pulsing function for each RAU discrete command if required by the hardware. If a command failure indication is received by the SC, an error message will be time-tagged and routed to the active Spacelab displays and to the PCMMU. The details of this tagged error are TBD.

The format for the CHW and the RIW are as follows:

Command Header Word (CHW). The CHW is the first word transmitted from ORBITER to SPACELAB.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A C K	Operation Code				Rec		C/O Ind		Spare		Number of valid data words (CDWs)				

Bit	Description
0	ACK - The acknowledge bit shall indicate the status of the last transmission received by the ORBITER. The "ack" bit is set to zero when the last transmission is received and recognized as valid. The "ack" bit shall be set to one in case of hardware and / or software detected errors as described in Appendix A, Reference 5.
1-4	OPERATION CODE

Bit	Description
	Bit 1 indicates, this Operation Code is used for SPACELAB Hardware - or Software Control Mode:

Bit 1 = "0" SPACELAB in Software Control Mode

Bit 1 = "1" SPACELAB in Hardware Control Mode

The following Operation Codes apply for the Software Control Mode.

0111 - ACCEPT DATA
is normally used to request SCOS/ECOS to accept the data words within the MDM Message.

0001 - RETURN COMMAND HEADER WORD
is used for verification purposes to require a return of the CHW and a transmission of the SPACELAB MDM coupler status word.

0101 - RETURN(ORBITER) MDM MESSAGE
is used for verification purposes to require a return of the content (31 data words following the CHW) of the MDM Message.

0011 - RETRANSMIT LAST MDM MESSAGE
is used to request a retransmission of the previous MDM Message issued by SPACELAB.

The following Operation Codes apply for the Hardware Control Mode.

1100 - LOAD
is used to write up to 30 data words consecutively into the addressed SPACELAB core memory words.

1110 - LOAD + DUMP
is used to write up to 30 data words consecutively into the addressed SPACELAB core memory and then to read and transmit the same words back to the ORBITER in the next MDM Message.

Bit	Description
	1010 - DUMP is used to read and to transmit 30 data words from the addressed SPACELAB core memory to the ORBITER.
	1001 - RETURN COMMAND HEADER WORD is used for verification purposes to require a return of the CHW and a transmission of the SPACELAB MDM coupler status word.
	1000 - END OF LOADING is used to initiate the SPACELAB computer to switch from Hardware to Software Control Mode.
	All other bit combinations are illegal.
5,6	REC - Two bit code identifying the number of Record Identification Words within one MDM Message: 00 = 0 User Record 01 = 1 User Record 10 } illegal bit combination 11 } In Hardware Control Mode these bits will set to (00)
7,8	C/O Ind. In hardware control mode these bits will be set to (00) In software control mode, these two bits will be used for ATE C/O purposes and will be set to zero when interfacing with the GPC.

Bit	Description
9,10	SPARE These bits bill be set to (00)
11-15	NUMBER OF VALID DATA WORDS (CDW) A five bit code (LSB is bit 15) indicating the number of valid data words within the MDM Message (including the CHW): 00000 = 1 data word (CHW) 00001 = 2 data words • • • 11111 = 32 data words

Record Identification. The RIW is the first word of a user record within an MDM message.

Record Identification Word (RIW)

0	1	2 3 4 5 6 7 8 9 10	11 12 13 14 15
E O R	T S C P	RI	NUMBER OF USER RECORD WORDS (CDW's)

Bit	Description
0	End of user record (EOR) This bit when set to "0" indicates that this user record is completely transmitted within this MDM message. Bit 0 set to "1" indicates that this user record will be continued.
1	TWO STAGE COMMAND PROCESSING (TSCP) This bit set to "1" indicates that the content of this MDM message shall be verified by the sender through PCM downlink before it is transmitted to the user. This bit will be always set to 0 within the MDM messages sent to the Orbiter.
2-10	RECORD IDENTIFICATION CODE (RI) 32 bit combinations are reserved for the identification of service records. 480 bit combinations are available for the identification of application records, to specify command functions, receiver addresses for S/L User S/W and data types.
11-15	NUMBER OF USER RECORD WORDS A five bit code (LSB is bit 15) indicating the number of data words within this User Record (including the RIW) as contained within this MDM Message: 00000 - 1 data word (RIW) 00001 - 2 data words . . . 11110 - 31 data words (maximum)

5.5.1 <u>SSPC Load</u>. The function of this command is to load S/L Commands into the Spacelab Stored Program Command (SSPC) buffer. The general layout of the SSPC Command is given in Figure 5.5-1.

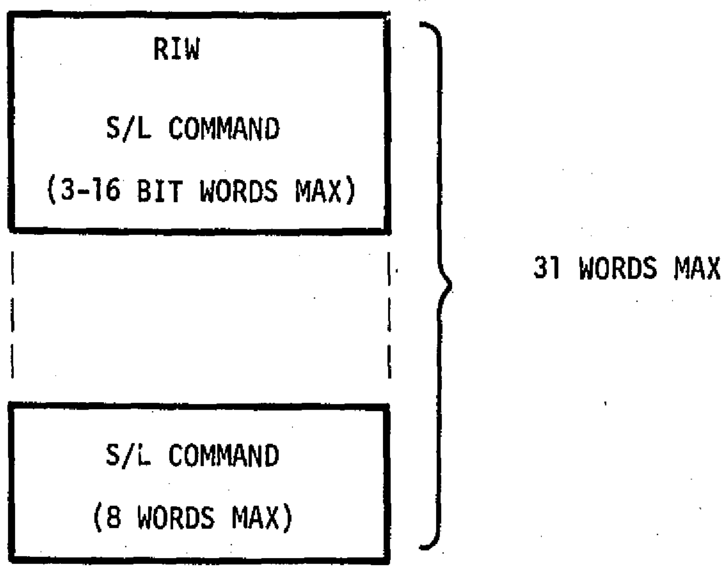
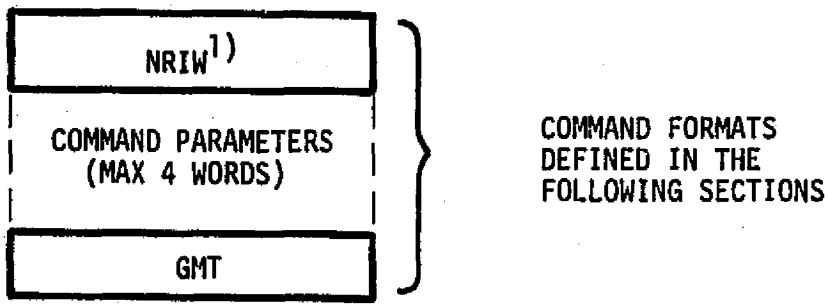


Figure 5.5-1 SSPC Load Record

Each S/L command to be put into the SSPC includes the GMT at which the command is to be executed and its length is limited to 8 words including the Nested RIW (NRIW). The (NRIW) has the same value as the RIW for each command. The S/L commands which can be stored in the SSPC buffer are limited to:

- Issue discrete
- Issue multiple discretes
- Write serial with fixed data
- HRM format load from MMU
- Start task
- Load memory configuration from MMU
- Cancel

The S/L commands identified above have the general format shown in Figure 5.5-2.



1) TSCP bit is always to be set to zero.

Figure 5.5-2 General Format of S/L Commands Transferred to the SSPC

5.5.2 Issue Discrete. This command function shall issue a RAU/HRM discrete function. An ID number identifies the command/end item function. Figure 5.5-3 shows the layout of the issue discrete record.

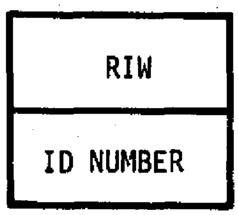


Figure 5.5-3 Issue Discrete Record

5.5.3 Issue Multiple Discrete. This command function causes one or more RAU/HRM discrete functions to be issued. This command function will use multiple command ID numbers to identify the RAU/HRM discrete commands to be issued. Figure 5.5-4 shows the layout of the issue multiple discrete record. The number of commands is indicated in the CDW field of the RIW.

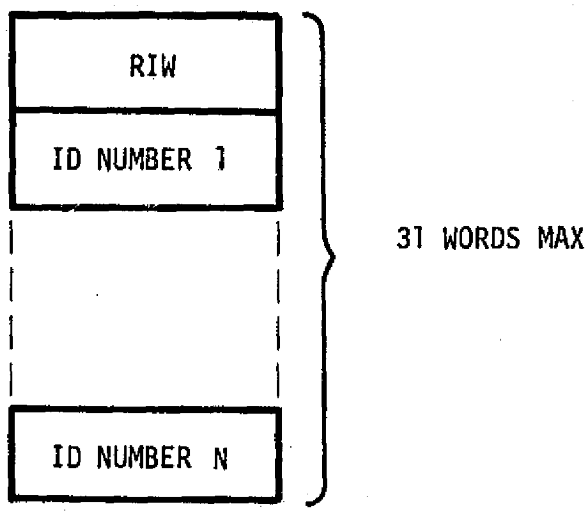


Figure 5.5-4 Issue Multiple Discrete Record

5.5.4 Write Serial With Fixed Data. This command function causes a serial output command to be issued. An ID number shall identify the RAU serial output channel if required and the command data words which shall be sent to that channel.

Figure 5.5-5 shows the layout of the write serial with fixed data record.

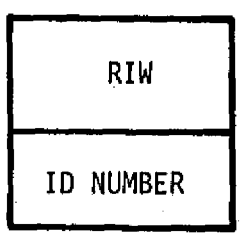


Figure 5.5-5 Write Serial With Fixed Data Record

5.5.5 <u>Write Serial With Variable Data</u>. This command function causes an RAU serial output command to be issued. An ID number shall identify the RAU serial output channel. The command data words (up to a maximum of 29) shall be included in the record. The format of the write serial with variable data record is shown in Figure 5.5-6.

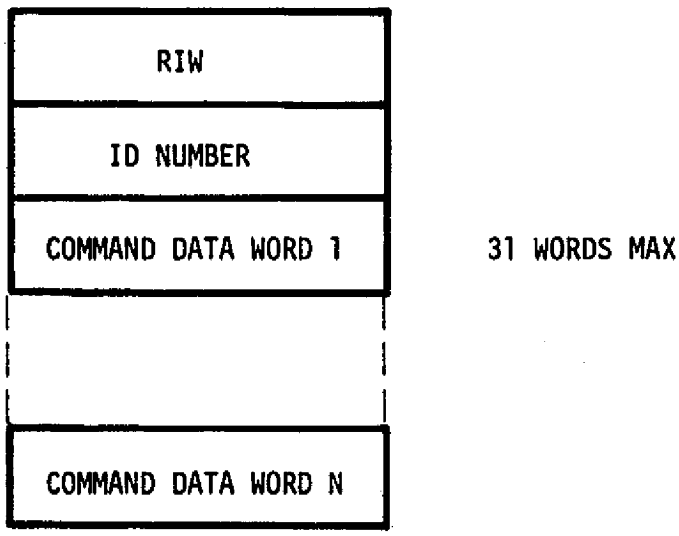


Figure 5.5-6 Write Serial With Variable Data Record

5.5.6 <u>HRM Format Load Via MMU</u>. This command allows a high rate multiplexer (HRM) format to be read from the MMU and loaded into the HRM format buffer. The format of the HRM format load via MMU record is shown in Figure 5.5-7.

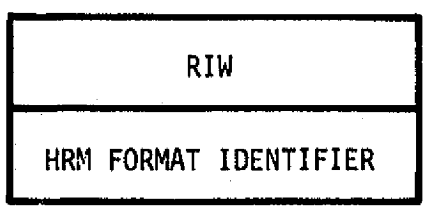


Figure 5.5-7 HRM Format Load Via MMU Record

5.5.7 HRM Format Load Via MDM. This command provides for uplink transmission of a HRM format to the HRM format buffer. The layout of the HRM format load via MDM record is shown in Figure 5.5-8.

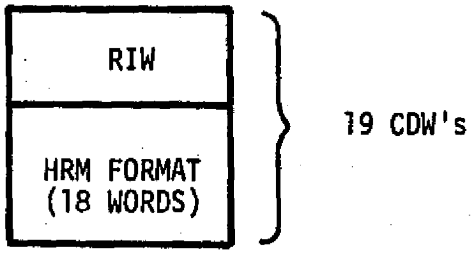


Figure 5.5-8 HRM Format Load Via MDM Record

5.5.8 Write Core Memory. This command allows up to 29 consecutive words to be written into core memory starting from a given absolute word address. The write core memory record is shown in Figure 5.5-9.

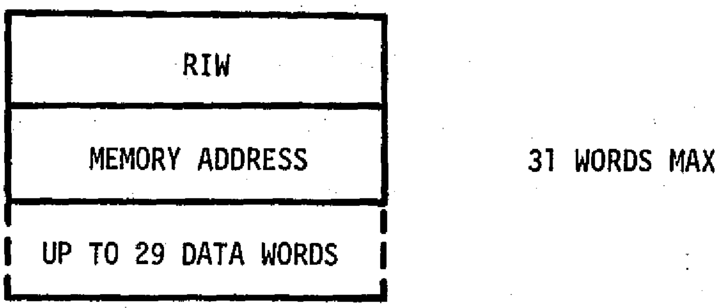


Figure 5.5-9 Write Core Memory Record

5.5.9 Write Core Memory Scatter. This command allows non-contiguous locations in core memory to be changed. Each change is described by the absolute word address and the single data word to be written to that location. The format of the write core memory scatter record is shown in Figure 5.5-10.

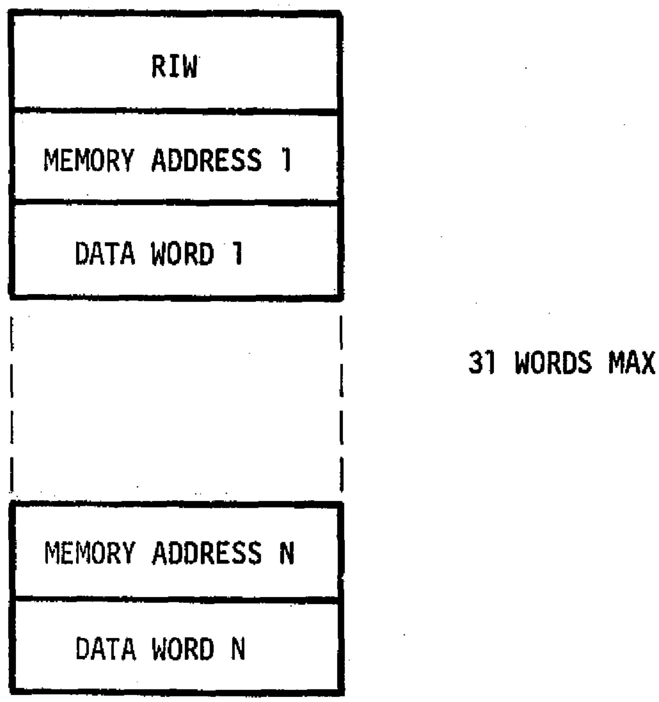


Figure 5.5-10 Write Core Memory Scatter Record

5.5.10 Cancel. The task specified by its name shall be stopped in an orderly manner. The format of the cancel record is shown in Figure 5.5-11.

RIW	
1	2
3	4
5	6

(6 ASCII CHAR)

Figure 5.5-11 Cancel Record

5.5.11 Terminate. This command is used to immediately stop execution of the specified task. The format of the terminate record is shown in Figure 5.5-12.

RIW	
1	2
3	4
5	6

(6 ASCII CHAR)

Figure 5.5-12 Terminate Record

5.5.12 Start Task. This command shall cause a single task to be activated. The task is required to be core resident. The format of the start task record is shown in Figure 5.5-13.

RIW	
1	2
3	4
5	6

(6 ASCII CHAR)

Figure 5.5-13 Start Task Record

5.5.13 Load Memory Configuration from MMU. This command shall be used to load a memory configuration from the MMU. The configuration is identified by its name. The format of the load memory configuration from MMU record is shown in Figure 5.5-14.

RIW	
1	2
3	4
5	6

(6 ASCII CHAR)

Figure 5.5-14 Load Memory Configuration From MMU Record

5.5.14 Dump Core Memory. The dump core memory provides the capability to dump the contents of a block of contiguous core memory locations via the PCMMU. The command specifies the absolute word address of the start of the dump and the number of words to be dumped. The format of the dump core memory record is shown in Figure 5.5-15.

RIW
START ADDRESS
TOTAL NUMBER OF WORDS

Figure 5.5-15 Dump Core Memory Record

5.5.15 Dump MMU Block. The dump MMU Block command provides the capability to dump the contents of a MMU block via the PCMMU. The command specifies the physical MMU block address of the block to be dumped.

The format of the dump MMU block record is shown in Figure 5.5-16.

RIW					
0 0	TRACK	FILE	SUBFILE	BLOCK NUMBER	MMU HARDWARE ADDRESS

Figure 5.5-16 Dump MMU Block Record

5.5.16 Load Memory Configuration from MDM. This command provides the capability for loading a memory configuration from the MDM into the core memory. The records for the new configuration are received from the MDM via the RECEIVE MEMORY LOAD AR. The format of the load memory configuration from MDM record is shown in Figure 5.5-17.

RIW	
1	2
3	4
5	6

(6 ASCII CHAR)

Figure 5.5-17 Memory Configuration Record

5.5.17 Checkpoint Initialize. This command allows a pre-mission defined set of data to be stored on MMU. The checkpoint data file is defined for each memory configuration. Figure 5.5-18 shows the format of the checkpoint initialize record.

RIW

Figure 5.5-18 Checkpoint Initialize Record

5.5.18 Checkpoint Retrieval. This command shall cause the retrieval of the last valid checkpoint data stored on the MMU for the current memory configuration. The format of the checkpoint retrieval record is the same as that shown in Figure 5.5-18.

5.5.19 Change Monitor Data. This command supports the changes as described in Table 5.5-1 to the monitor data of one specific item identified by an ID number. The change monitor data record is shown in Figure 5.5-19.

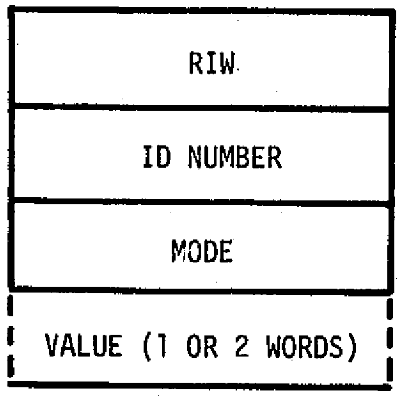


Figure 5.5-19 Change Monitor Data Record

TABLE 5.5-1 SUPPORTED CHANGES OF MONITOR DATA

MODE	FUNCTION	VALUE	TYPE	REMARK
1	ENABLE MONITORING	0	INTEGER	
1	INHIBIT MONITORING	1	INTEGER	
2	CHANGE UPPER LIMIT	UPPER LIMIT	SCALAR	ENG UNITS
3	CHANGE LOWER LIMIT	LOWER LIMIT	SCALAR	ENG UNITS
4	CHANGE N-COUNTER	N-COUNTER	INTEGER	
5	CHANGE EXPECTED STATE	EXPECTED STATE	INTEGER	UNCALIBRATED

5.5.20 Clear SSPC Buffer. This command shall clear and zero the entire SSPC buffer. The format is a single RIW as shown in Figure 5.5-18.

5.5.21 Clear Two Stage Buffer. This command shall cause the two stage buffer to be cleared to zero and released for the receipt of another MDM message with the same or different RI. The format is a single RIW as shown in Figure 5.5-18.

5.5.22 Execute Two Stage Buffer. This command shall validate the message in the two stage buffer and zero buffer for further processing as a command or application record. The format is a single RIW as shown in Figure 5.5-18.

5.5.23 MET Initialize. This command provides the GMT time at which the MET time base began. The format of the command record is shown in Figure 5.5-20.

RIW
CMTO

Figure 5.5-20 MET Initialize Record

5.5.24 Set CDT Active/Inactive Bit. This command shall either set or reset the active/inactive bit in the CDT entry designated by the ID number. If the bit is set to active (value = 0), then access of the associated end-item by application software is allowed. If the bit is set inactive (value 1), access is precluded. The format of the set CDT active/inactive bit record is shown in Figure 5.5-21.

RIW
ID NUMBER
VALUE (INTEGER)

Figure 5.5-21 Set CDT Active/Inactive Bit Record

5.5.25 Switch to Master Timer Unit (MTU). This command shall force the S/L computer to use the MTU as the realtime clock. The format of the record is a single RIW as shown in Figure 5.5-18.

5.5.26 Declare DPA End-Item OP/NOP. This command sets the status of a DPA end-item to either operational (state = 0) or non-operational (state = 1). If the status is set to non-operational, no S/L asynchronously initiated I/O involving this item is performed and the self test function for this item is disabled. The DPA end-item is defined by a 2-character device name and a sub-address which is a 16-bit integer number as shown in Table 5.5-2.

Figure 5.5-22 shows the format of the declare DPA end item OP/NOP record.

TABLE 5.5-2 MNEMONICS FOR DPA END-ITEMS

DEVICE NAME	SUB-ADDRESS	DPA END ITEM
RA	-1	RAU COUPLER
RA	0 TO 31	RAU/HRM
KB	0 TO 5	KEYBOARD COUPLER
DD	-1	DDS COUPLER
DD	0 TO 5	DISPLAY COUPLER
MU	N/A	MMU COUPLER

RIW
DEVICE NAME (2 ASCII CHARACTERS)
SUB-ADDRESS (INTEGER)
STATE (INTEGER)

Figure 5.5-22 Declare DPA End-Item OP/NOP Record

5.5.27 Orbiter Position Vector (GTOD). This record is transmitted by the Orbiter to update the Orbiter position vector data in S/L at a TBD period.

The AR includes the current Orbiter position and velocity vector in Greenwich time of day (GTOD) co-ordinate system, format TBD.

5.5.28 Orbiter Attitude Vector (GTOD). This AR is transmitted by the Orbiter to update the Orbiter attitude vector data in S/L at a TBD period.

The attitude is expressed as Euler angles and quaternion relative to the Greenwich TOD co-ordinate system, and the attitude rates are measured in the Orbiter body axes. The format of the record is TBD.

5.5.29 Orbiter Position/Attitude Vector in Aries Mean of 1950 Coordinates. This record is transmitted by the Orbiter to update the Orbiter position and attitude data in S/L at TBD time period.

The record includes the current Orbiter position and velocity vectors and the attitude quaternion in Aries Mean of 1950 inertial coordinate system. The format of the record is TBD.

5.5.30 Read MMU. This command shall provide the capability to read one block of MMU to a fixed S/L modification buffer. The MMU block is defined by its physical address. The format of the read MMU record is TBD.

<table>
<tr><td colspan="5">RIW</td><td></td></tr>
<tr><td>00</td><td>TRACK</td><td>FILE</td><td>SUBFILE</td><td>BLOCK NUMBER</td><td>MMU HARDWARE ADDRESS</td></tr>
</table>

Figure 5.5-23 Read MMU Record

5.5.31 Write MMU. This command shall provide the capability to write one block from a fixed S/L modification buffer to the MMU. The MMU block is defined by its physical address. The write is performed with no checksum or redundancy processing.

5.5.32 Update RTC GMT. This command is used to correct the S/L internal time after the S/L has sensed an MTU failure and reverts to internal time. The parameters consist of two values of GMT.

The first value denotes the time, according to the current internally maintained GMT time, when the correction is to occur. The second value of GMT denotes the corrected value of GMT. The format of the update RTC GMT record is shown in Figure 5.5-24.

RIW
TIME OF CORRECTION
CORRECTED TIME

Figure 5.5-24 Update RTC GMT

5.5.33 Receive Memory Load. Figure 5.5-25 gives the layout of the receive memory load AR. The record may be extended via several MDM messages.

RIW
TASK AMI OR MCT

Figure 5.5-25 Receive Memory Load AR

5.5.34 ID Numbers for S/L Commands. The ID number associated with a S/L command is represented by a 16-bit integer less than or equal to decimal 9999 for all S/L computers. ID numbers are used in the following commands:

- Issue discrete
- Issue multiple discrete
- Write serial with fixed data
- Write serial with variable data
- Change monitor data
- Set CDT active/inactive bit

An ID number identifies a CDT entry which in turn identifies a H/W or S/W end item. No specific processing is implied by an ID number.

Table 5.5-3 gives the ID numbers allocated to each S/L computer.

TABLE 5.5-3 ID NUMBER ALLOCATION

	TOP LEVEL GROUPING	ID NUMBER ALLOCATION			
		LOWER LEVEL BREAKDOWN	SIZING	LOWER LEVEL GROUPING	SIZE OF GROUP
EXPERIMENT COMPUTER	3000 TO 6999	SOFTWARE H/W MEASUREMENT H/W STIMULI		3000-6399	3400
		INTEGRATION AND TEST SPECIAL	100	6400-6499	100
		RESERVE/GROWTH	500	6500-6999	500
SUBSYSTEM COMPUTER	0000 TO 2999	SOFTWARE[a]	400	0000-0399	400
		H/W MEASUREMENT	587	0400-1499	1100
		H/W STIMULI	300	1500-2299	800
		INTEGRATION AND TEST SPECIAL	100	2400-2499	100
		EXPT CAUTION AND WARNING	100	2300-2399	100
		RESERVE/GROWTH	500	2500-2999	500
ATE COMPUTER	7000 TO 9999	SOFTWARE	400	7500-7899	400
		H/W MEASUREMENT (MSU & SCCD)	781	7900-9099	1200
		H/W STIMULI (MSU & SCCD)	395	9100-9699	600
		INTEGRATION AND TEST SPECIAL	300	9700-9999	300
		RESERVE/GROWTH	500	7000-7499	500

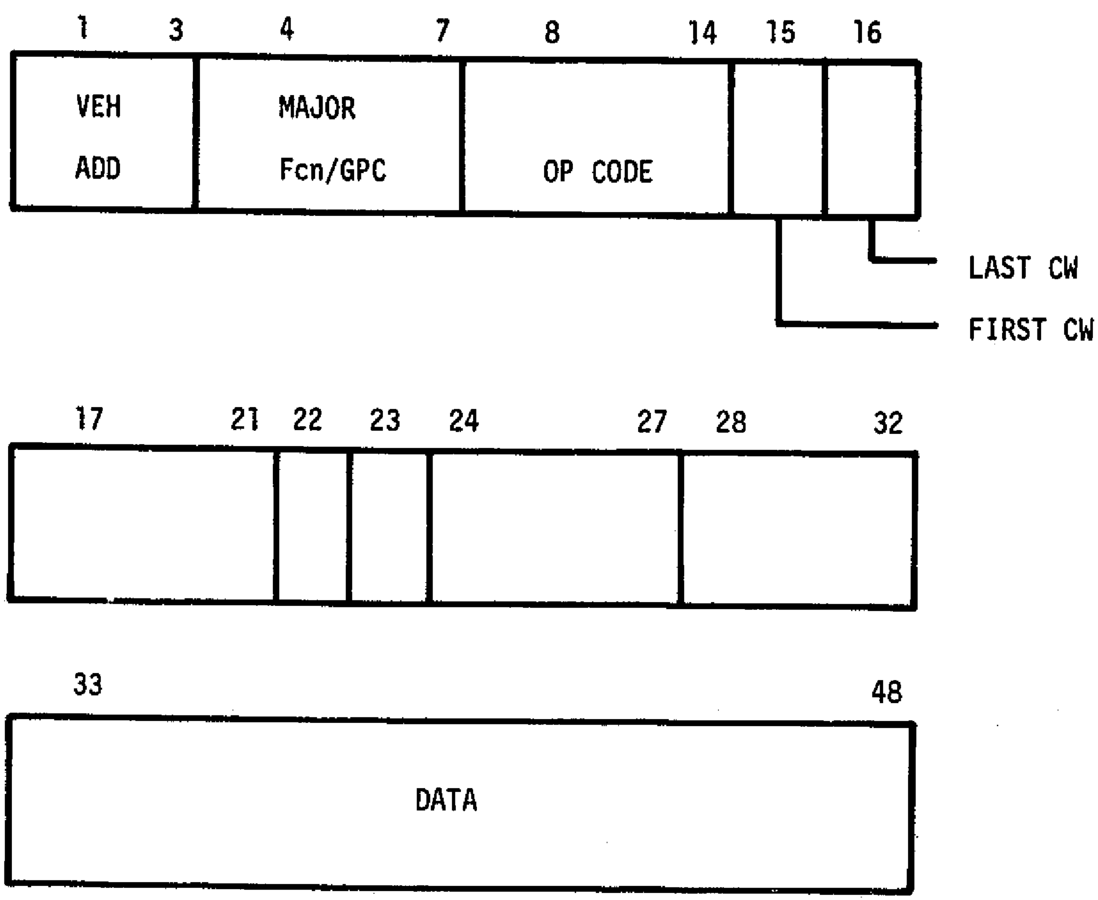
NOTE (a). THIS IS TO INCLUDE S/W ID NUMBERS FOR IPS

5.6 ORBITER UPLINK FORMAT FOR S/L COMMANDS

The Spacelab uplink format is as shown in Figure 5.6-1.

5.6.1 Spacelab Serial Data Load. The Spacelab serial data load is used to throughput data to the Spacelab computers. The definition of the load is specified below.

Command Word (1)



Bits	Description
1-3	VEH ADD - Orbiter Vehicle Address
	000 - Illegal
	001 - Illegal
	010 - Vehicle 102
	011 - Vehicle 103
	100 - Vehicle 104
	101 - Vehicle 105
	110 - Vehicle 106
	111 - Vehicle 107
4-7	SM major function OP code (1000)
8-14	Spacelab serial data load OP code (TBD)
15-16	As applicable
17-21	Fixed to "00111"
22	Indicates destination of data (1=Spacelab Subsystem Computer; 0=Spacelab Experiment Computer)
23	Fixed to "1"
24-27	Fixed to "0000"
28-32	Indicates number of data words in the load
	00000 = 0 data words
	11111 = 31 data words
33-48	This is the first data word of the load and shall always contain the Record Identification Word (RIW). Refer to the payload FSSR for definition of the RIW's and subsequent record data words for Spacelab serial data loads.

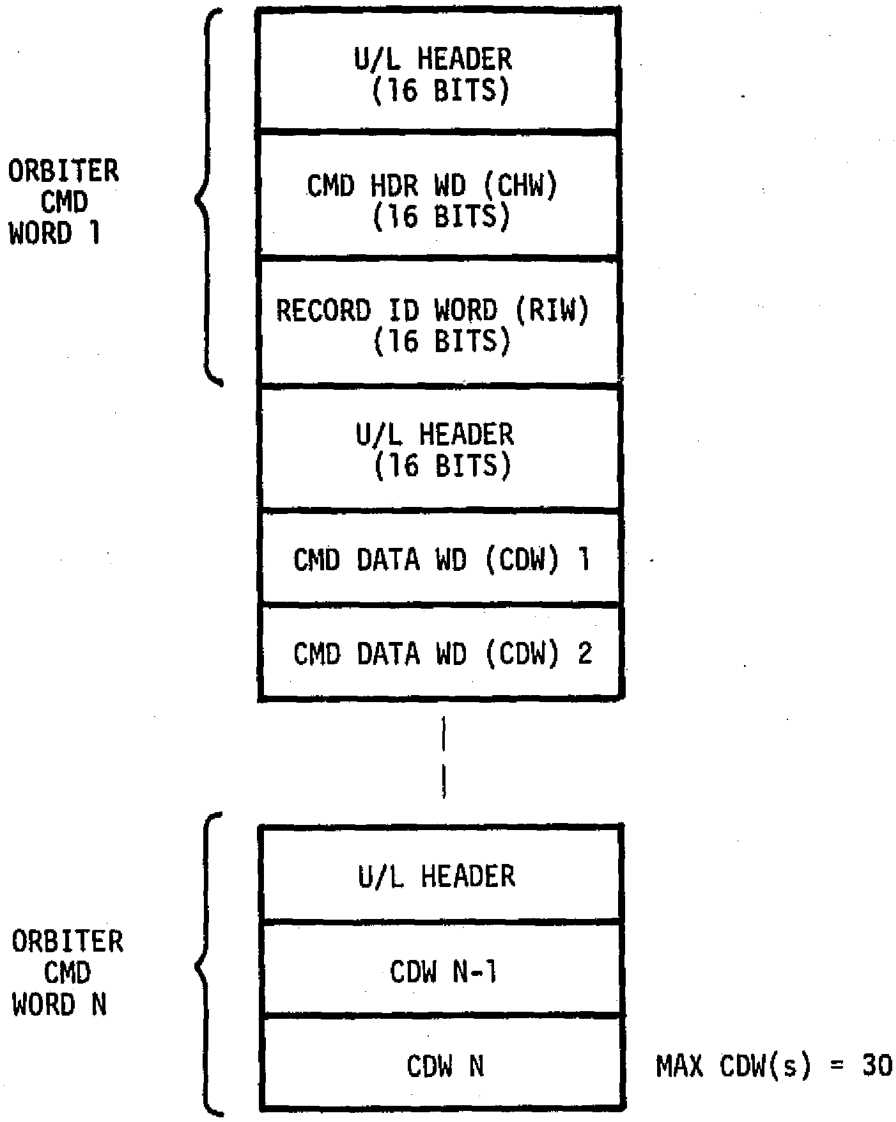
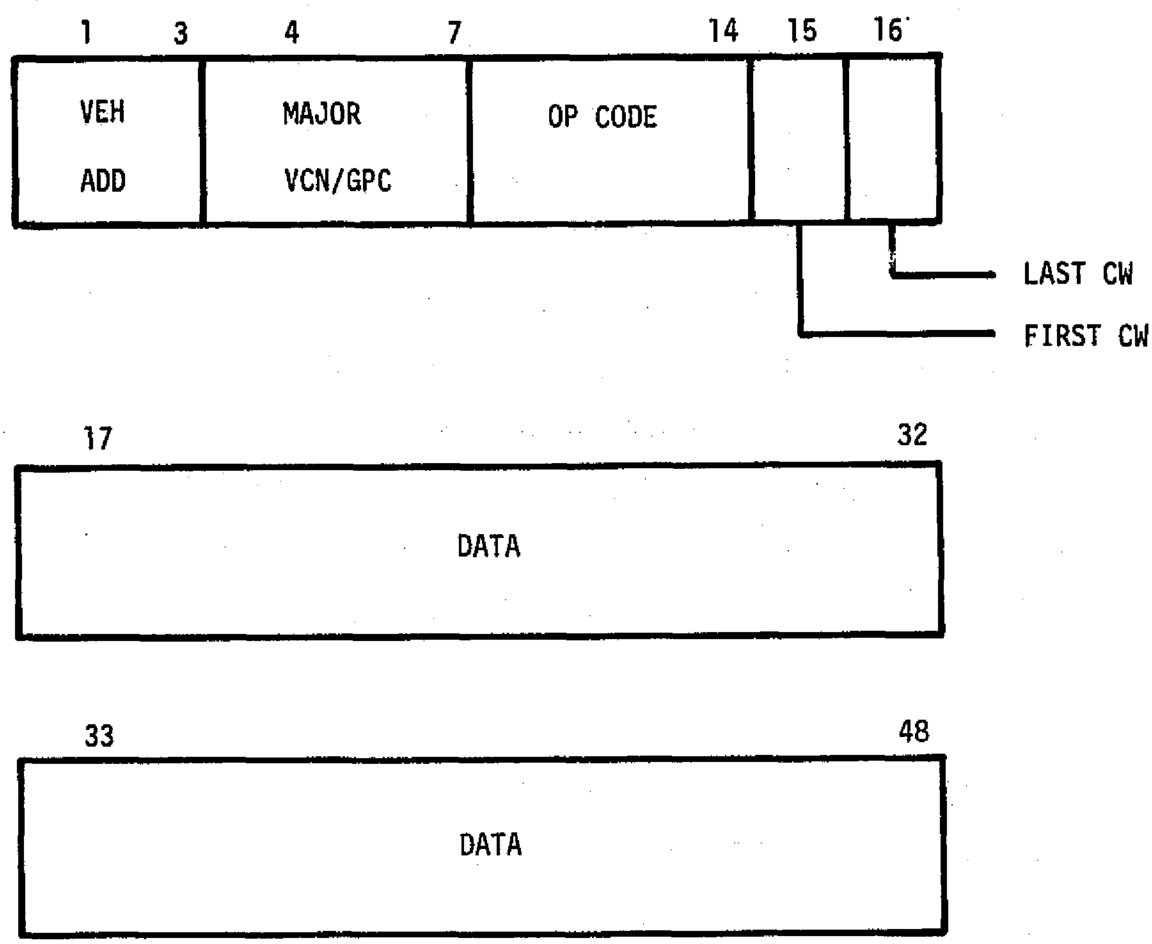


Figure 5.6-1 Spacelab U/L Message Format

CW 2 through CW n ($N \leq 16$)



Bits	Description
1-16	Same as CW 1
17-32	Contains one of up to 30 Spacelab serial data load record data words which follow the RIW.
33-48	Same as bits 17-32 (if the number of data words following the RIW is odd, bits 33-48 of CW n shall be arbitrary fill data).

5.6.2 Sample Command Format. Figure 5.6-2 shows an example of the coding for a Spacelab write core memory command.

The coding shown illustrates a command of maximum length consisting of 30 CDW's.

Each Orbiter command is 48 bits in length, containing 2-16 bit S/L CMD words. The first 16 bits of each Orbiter command word is an overhead word.

The second and third 16 bit segments in Orbiter word 1 contain the S/L CHW and RIW with codes as defined in this section. The following Orbiter words (Bits 17-48) contain the S/L command data words (CDW).

BIT NUMBER

SPACELAB UPLINK/ DOWNLINK WORDS	VEH ADD (1–3)	MAJ FUNC (4–7)	OP CODE (8–14)	FCW (15)	LCW (16)	DATA (17–32)	DATA (33–48)	ORBITER CMD WORD
1-2-3	V V V	1 0 0 0	TBD	1	0	1 0 1 1 1 0 1 0 0 0 0 1 1 1 1 1	0 1 0 0 0 1 0 1 1 0 0 1 1 1 1 0	1
4-5				0	0	CDW	CDW	2
6-7								3
8-9								4
10-11								5
12-13								6
14-15								7
16-17								8
18-19								9
20-21				0	0			10
22-23	V V V	1 0 0 0	TBD	0	1	CDW	CDW	11
24-25								12
26-27								13
28-29								14
30-31								15
32-33								16

V - VEHICLE ADDR (ORBITER)
CDW - S/L CMD DATA WORD

AA10966(B)-3

Figure 5.6-2 Spacelab CMD Format for Write Core Memory

5.7 DATA FORMATS

5.7.1 Number Description

A. Integer

	MSB		LSB
Word 1	0 S	Binary value	15

sign bit

16 bit integer

	MSB		LSB
Word 1	S	Binary value	
Word 2			

32 bit integer

Sign = 0 ⟷ +

1 ⟷ -

Negative values are represented in a 2's complement

B. Scalar

	MSB 0	7	LSB 15
Word 1	S	C	
2	MANTISSA (m)		

Scalar

A scalar n is defined by its mantissa m, its exponent e, the base B of the exponent and its sign:

$$n = \pm m B^{e}$$

$$B = \text{base} - 16$$

$$e = \text{exponent} = C_{1-7} - 64$$

$$m = \text{mantissa} = M_{8-31} = \sum_{i=1}^{24} a_t \, 2^{-i}$$

$$S = \text{sign} = 0 \longleftrightarrow +$$

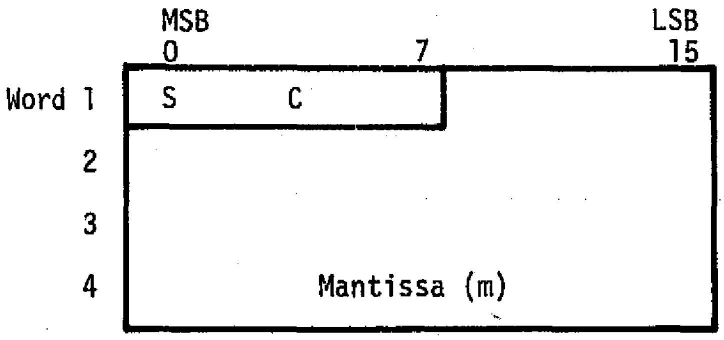
$$1 \longleftrightarrow -$$

A negative number is represented by the two's complement of the 32 binary digits of its absolute value. The scalar used during communication shall be normalized.

A positive scalar is normalized if its mantissa is larger than or equal to 1/16.

A negative scalar is normalized if its absolute value is normalized.

C. Double Scalar



A double scalar n is defined by its mantissa m, its exponent e, the base B of the exponent and its sign:

$$n = \pm m B^{e}$$

$$B = \text{base} = 16$$

$$e = \text{exponent} = C_{1-7} - 64$$

$$m = \text{mantissa} = M_{8-63} = \sum_{i=1}^{i=56} a_i \, 2^{-i}$$

$$S = \text{sign} - \emptyset \longleftrightarrow +$$
$$1 \longleftrightarrow -$$

A negative number is represented by the two's complement of the 64 binary digits of its absolute value.

A positive double scalar is normalized if its mantissa is larger than or equal to 1/16.

A negative double scalar is normalized if its absolute value is normalized.

A double scalar Ø is represented by S=C=M=Ø.

The negative number 8000 0000 0000 0000 is not processed.

5.7.2 GMT. The GMT is represented by a 16 bit integer which specifies the day within the year and a 32 bit integer which gives the time in the day in multiple of 10 msec.

1st January is day 1

0	day in the year	(16 bit integer)
0	time of the day in multiple of 10 ms	32 bit integer

GMT

SECTION 6

HIGH RATE DEMULTIPLEXER OUTPUT TELEMETRY FORMATS

6.1 OVERVIEW

This section describes the telemetry data format characteristics anticipated for the early Spacelab flights. The parameters used to describe these formats are those which directly or indirectly effect the MCC/POCC's ability to synchronize with, decommutate/preprocess, record, and process/display this data for MCC/POCC users.

Specific data link formats to be considered in this section include the direct access channels, the 16 individual experiment links, the Spacelab subsystem and computer I/O channels, GMT time word formats, HRM/HRDM configuration status words, the Spacelab recorder links, and the three Spacelab voice channels. The source of all of the above links is the input to the Spacelab High-Rate Data Acquisition System (HRDAS).

The 4.2 MHz analog (FM) data link formats are not considered since there is no requirement to demodulate FM multiplexed data in the POCC.

In the event that this link is used to transmit digital data, the formats the POCC will process will be constrained by the standard formatting recommendations in paragraph 6.2.2.3.

In addition to the above formats, this section includes detailed formats of three typical Spacelab experiments and the payload formats for Spacelab Flight 1.

6.2 EXPERIMENT TELEMETRY FORMATS

6.2.1 Direct Link Experiment Formats. The HRDAS provides direct access channels on which experimenters can downlink data, i.e., bypass the MUX formatter and use the full bandwidth of the system. In this operating mode, formatting is constrained by the standard formatting described in paragraph 6.2.2.3. The downlink frequencies are 0.125, 0.25, 0.5, 0.75, 1.0, 2.0, 4.0, 8.0, 16.0, 32.0, and 48 Mb/s.

6.2.2 Multiplexed Experiment Formats. Up to 16 input ports are available to SL experimenters for inputting their unique PCM data streams. The HRM input allows the experimenter a wide range of flexibility for bit rate selection and unique format structure; in fact, the experimenter is constrained only by the following:

- The input data must be PCM NRZ-L code
- The input bit rate, averaged over any sequence of 64 bits, must be no higher than the nominal data rate allocated to the user (input buffer constraint)
- The peak bit rate must not exceed 16 Mb/s (HRM input circuit hardware constraint).

The experimenter delivering serial data to the HRM will, on the ground, recover his data from the HRDM completely unchanged. This means that the user himself has to take care of the formatting and structuring of his serial data. To facilitate this task, each HRM experiment channel can operate in two different modes, as described below.

A. Normal Mode. In this mode, the word structure in the HRM output frames is not correlated with any structure of the input data. The serial input data is arbitrarily chopped into 16-bit words for parallel processing inside the HRM. Consequently, the user must insert some kind of sync pattern into his serial input bit stream in order to be able to extract, on the ground, his scientific data from the serial bit stream of his output channel.

B. Word Pattern Transparency Mode. In this mode, the input data can be structured in words that, after multiplexing, can be identified as words in the HRM output frames in those positions determined by the chosen format. Synchronously with the frame or format pulse (which indicates the beginning of a new frame or format, respectively), experiment data can be delivered to the HRM in bursts of 16-bit words. Because the clock counter is reset at the beginning of each format, these words are identical to the internal words the HRM handles in parallel. In this mode, the HRDM delivers the data words without bit rate smoothing at the nominal bit rate allocated to the particular experiment channel. The full definition of this mode is TBD.

The mode (normal or word pattern transparency) of each input channel is determined by an external HRM connector. This connector is programmed by hardwired jumpers on a mission-to-mission basis.*

6.2.3 Telemetry Format Standards. Telemetry format standards for the data to be processed in the POCC are contained in JSC-14433, *POCC Capabilities Document*.

*This mode is not supported by the JSC POCC.

6.3 HRM/HRDM COMPUTER I/O

Both the subsystem and experiment computers output a serial PCM telemetry format to the ground via the BIU interfaces at the HRM. The POCC does not process the subsystem I/O, therefore, this data stream will not be described. The format for the experiment computers is described in appendix K. These pages are extracted from the MSFC Spacelab 1 POCC Requirements Document dated 28 November 1978.

6.4 HRM/HRDM GMT FORMAT

The GMT and flight number data which is subcommutated across the 16 frames of the engineering format will be output in a serial burst of 56 bits once each engineering format. The format of the HRDM output will be as shown below.

• Flight No. (0-99):	0 … 7
• Year + Day (× 100) (0-9/0-9):	8 … 15
• Days (0-99):	16 … 23
• Hours (0-23):	24 … 31
• Minutes (0-59):	32 … 39
• Seconds (0-59):	40 … 47
• Seconds (÷ 100) (0-99):	48 … 55

The data is BCD coded inside the pattern. Synchronously with the beginning of each engineering format, the GMT pattern will be serially output (bit zero first) from the HRDM in a burst of 56 bits. The GMT output bit rate shall be equal to the HRDM input bit rate divided by 512.

The seconds (÷ 100) shall be decommutated from the first frame of a format.

The HRDM shall provide one GMT output. The data shall be NRZ-L coded and the output shall consist of data and gated clock lines.

6.5 HRM/HRDM STATUS

The operational and configuration status of the HRM will be obtained from two sources:

- Configuration status included in the HRM output format
- Status the S/S computer obtains by interrogating the HRM periodically.

Status from the first source is displayed on the HRDM front panel as the data is demultiplexed and is also available (via the MSU interface) to the ground processor controlling the HRDM. The contents of this status source is described in paragraph 6.5.1.

The routing of the HRM status obtained by the subsystem computer is not clearly defined at this time. The capability exists for this status to be routed to the ground via the PCMMU interleaved in the Orbiter downlink, and/or the status can be routed via the HRM through the subsystem I/O channel. The status information which will be available is described in paragraph 6.5.2.

6.5.1 HRM Configuration Status Words. The first two words of alternate user format frames (words 96 and 97 of the engineering format) contain the HRM configuration status and the subcommutated GMT. Since this data is obtained from the HRDM via a processor, the ultimate format to be supplied to the user is to be determined. The status information available is summarized in tables 6-1 and 6-2.

TABLE 6-1

HRM CONFIGURATION STATUS WORD 1

0–7	8	9–14	15
GMT (BIT 0 = MSB; SEE BELOW)	CHANGE FORMAT FLAG	FORMAT IDENTIFICATION*	PLR ROUTING**

*000000 = BITE FORMAT; ALL OTHER = TBD

**0 = OFF (NO SIGNAL OUTPUT); 1 = MUX

FRAME	CONTENT	RANGE
0, 2, AND 4-14	HUNDREDTHS OF SECONDS	0-99
1	SECONDS	0-59
3	MINUTES	0-59
5	HOURS	0-23
7	DAYS	0-99
9	YEAR AND DAY (X 100)	0-9/0-9
11	FLIGHT NO.	0-99
13	SPARE	-
15	SPARE	-

TABLE 6-2

HRM CONFIGURATION STATUS WORD 2

0 – 3	4 – 6	7 – 9	10 – 11	12 – 13	14 – 15
HRM FREQUENCY (MHZ)	HDRR REPRO FREQUENCY (MHZ)	KUSP 48 MHZ ROUTING	KUSP 4 MHZ ROUTING	KUSP 2 MHZ ROUTING	HDRR ROUTING

BITS 0-3	HRM FREQ (MHZ)
0000	0.125
1000	0.250
0100	0.500
1100	1.000
0010	0.125
1010	0.250
0110	0.500
1110	1.000
0001	0.125
1001	1.00
0101	2.0
1101	4.0
0011	8.0
1011	16.0
0111	32.0
1111	48.0

BITS 4-6	HDRR REPRO FREQ (MHZ)
000	2.0
100	4.0
010	8.0
110	12.0
001	16.0
101	24.0
011	32.0
111	

BITS 7-9	KUSP 48 MHz ROUTING
000	OFF
100	OFF
010	OFF
110	OFF
001	DACH NO. 1
101	DACH NO. 2
011	HDRR DIRECT DUMP
111	MUX

BITS 10-11	KUSP (4 MHz) ROUTING
00	OFF
10	PLR DIRECT DUMP
01	HDRR DIRECT DUMP
11	MUX

BITS 12-13	KUSP (2 MHz) ROUTING
00	OFF
10	PLR DIRECT DUMP
01	HDRR DIRECT DUMP
11	MUX

BITS 14-15	HDRR ROUTING
00	REPRO (DATA OFF)
10	DACH NO. 1
01	DACH NO. 2
11	MUX

6.6 HRM/HRDM RECORDER FORMATS

6.6.1 HDRR Formats. Data is recorded on the HDRR using NRZ-L plus clock recording technique, but the actual data format is dependent on the format of the source from which data is received and the mode in which the recorder dumps data to the ground. The HDRR can record and reproduce data formats from the direct experiment channels and from the HRM multiplexer unit (with multiplexed data from HDRR, payload recorder, direct experiment channels, experiment data bus, subsystem data bus, GMT, and voice). Recorder playback for dumping data to the ground is always in the reverse direction.

6.6.2 Payload Recorder Formats. Digital data is recorded on the payload recorder using the bi-phase L technique, but the actual data format is source and mode dependent. All digital data to the payload recorder is supplied through the HRM multiplexer unit as described under HDRR formats. The payload recorder is very flexible and has many operational modes (see paragraph 3.2.1.4). The number of modes will be preselected for a given flight. The ground processing equipment receiving payload recorder dumps will require a capability of detecting serial digital data in either forward or reverse direction.

6.7 HRM/HRDM VOICE FORMATS

The HRM accommodates three voice channels, coming from the SL intercom master station in module configurations and, if required, from the Orbiter ACCU in pallet-only configurations.

A HRM built-in voice digitizer performs the necessary analog/digital conversion for the three voice channels and the time-division multiplexing of the digitized voice signals.

The voice digitizer transforms each analog voice signal to a 32 kb/s digital signal; delta modulation is used for A/D conversion.

Each of the three voice digitizer circuits transmits four bits in parallel at a sampling frequency of 8 kHz into an input buffer; three bits for the ON/OFF status of each channel plus one spare bit complete the parallel 16 bits. Thus, if a configuration with voice is programmed, the bit rate to be allocated to this input is fixed at 128 kb/s.

The ground-based HRDM demultiplexes the voice channel and makes the composite (three-channel) digital voice available at an output port for potential recording. The HRDM also performs second-level demultiplexing of the voice channel, providing three separate digital voice channel outputs. Each of these channels are D/A converted using delta demodulation, and they appear as three analog voice channels at the HRDM output. Online internal distribution of these three analog voice channels is planned at the JSC POCC, as well as a capability to remote any channel to external users as required. The disposition of the digital form of the voice channels is TBD.

The characteristics of the output of the HRDM delta demodulator are as follows.

- 0 dbm ± 3 dbm
- Output bandwidth flat between 300 Hz and 2300 Hz
- Bandpass roll-off - 18 db, below 300 Hz and above 2300 Hz
- Output impedance - 600 ohms ± 1 percent
- Coupling: dc isolated and balanced (transformer coupling).

6.8 SPACELAB FLIGHT 1 PAYLOAD TELEMETRY FORMATS

This section defines the payload telemetry formats for flight 1. The format characteristics are described in table 6-3. Further details are contained in the following paragraphs.

6.8.1 Experiment INS001. Formats A & B for Experiment INS001, Imaging Spectrometric Observatory are shown in tables 6-4 and 6-5, respectively.

6.8.2 To be supplied.

•

•

6.8.16 To be supplied.

TABLE 6-3

SPACELAB FLIGHT 1 HRDM FORMATS

HRDM CHNL	EXP ID	BIT RATES KB/S	MAJOR FRAME RATE PERIOD SEC	MINOR FRAMES PER MAJOR FRAMES	WORDS PER MINOR FRAME	BITS PER WORD	SYNC PATTERN		FRM CNTR LOCATION	
							LOC	HEX	LOC	RANGE
1	INS013	512.	.2	40	32	8				
2	IES019	256.	.02	20	32	8				
3	IES020	1,000.	.002048	8	32	8				
4	IES023	42.	.1995	4	256	8				
5	IES034	377.	2.78	256	512	8				
6	IES201	204.8	.125	32	100	8				
7	INS001	2050.	.2	125	410	8	1,2,3	FA,F3,20		
7	INS001	255.84	1.0	78	410	8	1,2,3	FA,F3,20		
8	INS002	512.	1.0	250	256	8				
9	INS003	272684	1.3	256	173	8				
10	INS102	32.	.96	16	240	8				
11	INS104	4.	1.248	4	156	8				
12-15	SPARE									
16	TGA?	246.784	1.0	64	241	16	1,2,3			
DIRECT	IES034	32,000.	.3277	256	512	8				

TABLE 6-4

EXPERIMENT INS001, FORMAT A

FUNCTION / MINOR FRAME \ BYTE	SYNC CODE			FRAME COUNT	S/C - EXP DATA		ENGINEERING DATA				SPECTROMETER DATA
							WORD 1		WORD 2		200 WORDS 1 SPATIAL LINE
	1	2	3	4	5	6	7	8	9	10	11 ← → 410
1 2 3 4 5	FA ↓	F3 ↓	20 ↓	0 1 2 3 4	EXP ID GMT DDD GMT MM GMT S/100 EXP ID	EXP MODE GMT HH GMT SS MIS ID EXP MODE	ENG DATA FROM SM NO. 1 ↓				SM NO. 1 ↓ SM NO. 1 LINE NO. 1 ↓
6 ↓ 25	↓	↓	↓	5 ↓ 24	RESERVED ↓	RESERVED ↓	ENG DATA FROM SM NO. 2 ↓				LINE NO. 2 ↓ LINE NO. 5
26 ↓ 50	↓	↓	↓	25 ↓ 49	↓	↓	ENG DATA FROM SM NO. 3 ↓				LINE NO. 6 ↓ LINE NO. 10
51 ↓ 75	↓	↓	↓	50 ↓ 74	↓	↓	ENG DATA FROM SM NO. 4 ↓				LINE NO. 11 ↓ LINE NO. 15
76 ↓ 100	↓	↓	↓	75 ↓ 99	↓	↓	ENG DATA FROM SM NO. 5 ↓				LINE NO. 16 ↓ LINE NO. 20
101 ↓ 125	↓	↓	↓	100 ↓ 124	↓	↓	RESERVED ↓				LINE NO. 21 ↓ LINE NO. 25

$$2.05\ \mathrm{MB/S} = 410\ \frac{\mathrm{WORDS}}{\mathrm{FRAME}} \times 125\ \frac{\mathrm{MINOR\ FRAMES}}{\mathrm{MAJOR\ FRAME}} \times 8\ \frac{\mathrm{BITS}}{\mathrm{WORD}} \times 5\ \frac{\mathrm{MAJOR\ FRAMES}}{\mathrm{SEC}}$$

TABLE 6-5
EXPERIMENT INS001, FORMAT B

FUNCTION / MINOR FRAME \ BYTE	SYNC CODE			FRAME COUNT	S/C EXP DATA		ENGINEERING DATA WORD 1, WORD 2	SPECTROMETER DATA 200 WORDS, 1 SPATIAL LINE
	1	2	3	4	5	6	7 8 9 10	11 ⟷ 410
1	FA	F3	20	0	EXP ID	EXP MODE	ENG DATA FROM SM NO. 1	SM NO. 1 Σ LINES 1-8
2				1	GMT DDD	GMT HH		SM NO. 2 Σ LINES 1-8
3				2	GMT MM	GMT SS		SM NO. 3 Σ LINES 1-8
4				3	GMT S/100	MIS ID		SM NO. 4 Σ LINES 1-8
5				4	EXP ID	EXP MODE		SM NO. 5 Σ LINES 1-8
6				5	RESERVED	RESERVED		SM NO. 1 Σ LINES 9-16
7				6				SM NO. 2 Σ LINES 9-16
8				7				SM NO. 3 Σ LINES 9-16
9				8				SM NO. 4 Σ LINES 9-16
10				9				SM NO. 5 Σ LINES 9-16
11 – 20				10 – 19			ENG DATA FROM SM NO. 2	SM NO. 1 Σ LINES 17-24 ETC. SM NO. 5 Σ LINES 25-32
21 – 30				20 – 29			ENG DATA FROM SM NO. 3	SM NO. 1 Σ LINES 33-40 ETC. SM NO. 5 Σ LINES 41-48
31 – 40				30 – 39			ENG DATA FROM SM NO. 4	SM NO. 1 Σ LINES 49-56 ETC. SM NO. 5 Σ LINES 57-64
41 – 50				40 – 49			ENG DATA FROM SM NO. 5	SM NO. 1 Σ LINES 65-72 SM NO. 5 Σ LINES 73-80
51 – 75				50 – 74			RESERVED	SM NO. 1 Σ LINES 81-88 ETC. SM NO. 5 Σ LINES 113-120
76				75			RESERVED	RESERVED
77				76				
78				77				

AA10956(B)-4

$$255.840 \frac{\text{BITS}}{\text{SEC}} = 410 \frac{\text{WORDS}}{\text{FRAME}} \times 78 \frac{\text{MINOR FRAMES}}{\text{MAJOR FRAME}} \times 8 \frac{\text{BITS}}{\text{WORD}} \times 1 \frac{\text{MAJOR FRAME}}{\text{SEC}}$$

1. Messerschmitt-Bölkow-Blohm. *HRM CDR Final Design Report*, Vol. I.
2. Martin Marietta Corporation. MCR-77-429, *Spacelab High Rate Demultiplexer Final Design Report*, Final Issue. Denver, Colorado, September 1977.
3. Messerschmitt-Bölkow-Blohm, Space Division. HRM-50-EQ-MB-0031, *Unit Specification, High Rate Demultiplexer.* Ottobrunn, Germany, 3 March 1977.
4. NASA and ESA. SLP/2104, *European Space Agency Spacelab Payload Accommoda-Handbook*, Issue No. 1, 30 June 1977.
5. NASA-JSC. ICD-2-05301, *Shuttle Vehicle/Spacelab Avionics Interface Control Document*, Rev. B, 5 June 1977.
6. NASA-GSFC. SE-R-13109-01, *Interim Specification Recorder, Magnetic Tape, Wideband Digital Analog (Shuttle).*
7. NASA-MSFC, *Preliminary Downlink Format Guidelines.*
8. NASA-MSFC. *Preliminary Spacelab Mission 1 Integrated Payload Requirements Document*, Section 21, POCC Requirements Annex. 21 October 1977.
9. NASA-MSFC. *Preliminary Spacelab Mission 1 Integrated Payload Requirements Document*, Section 9, Command and Data Management System. 21 October 1977.
10. NASA-JSC. *Space Shuttle System Payload Accommodation Level II Program Definition and Requirements*, Rev. 23, Vol. XIV, Section 14, Avionics Subsystem. 10 November 1977.

LIST OF ACRONYMS AND ABBREVIATIONS

A/A	Air-to-Air
ACCU	Audio Central Control Unit
ACS	Attitude Control System
A/D	Analog to Digital
AFD	Aft Flight Deck (Orbiter)
A/G	Air-to-Ground
AMI	Absolute Memory Image
ATC	Air Traffic Control
BCD	Binary Coded Decimal
BCH	Bose-Chaudhuri-Hocquenghem
BER	Bit Error Rate
BITE	Built-In Test Equipment
BIU	Bus Interface Unit
BSR	BITE Status Request
CCTV	Closed Circuit Television
CDMS	Command and Data Management System
CHW	Command Header Word
C/O	Checkout
CPU	Central Processing Unit
CRT	Cathode Ray Tube
C&W	Caution & Warning
CWEA	Caution & Warning Electronics Assembly
D/A	Digital to Analog
DACH	Direct Access Channel
DDS	Data Display System
DDU	Data Display Unit
DEMUX	Demultiplexer
DEP	Dedicated Experiment Processor
DM	Development Model
DMA	Direct Memory Access
DOMSAT	Domestic Communications Satellite
DQM	Data Quality Monitoring

EC	Experiment Computer
ECAS	Experiment Computer Application Software
ECL	Emitter-Coupled Logic
ECOS	Experiment Computer Operating System
EIA	Electrical Industries Association
EOT	End of Transmission
ERSW	Error Status Word
ESA	European Space Agency
EVA	Extravehicular Activity
EXP	Experiment
FDA	Fault Detection and Annunciation
FIFO	First In, First Out
FM	Frequency Modulation; Flight Model
FSS	Fire Suppression System (Orbiter)
GML	General Measurement Loop
GMT	Greenwich Mean Time
GPC	General Purpose Computer
GSFC	Goddard Space Flight Center
GSTDN	Ground (components of) Spaceflight Tracking & Data Network
HDRR	High Data Rate Recorder
HDST	Headset
HRDA	High Rate Data Assembly
HRDAS	High Rate Data Acquisition System
HRDM	High Rate Demultiplexer
HRM	High Rate Multiplexer
ICMS	Intercom Master Station
ICOM	Intercom Channel
ICRS	Intercom Remote Station
ID	Identification
IMCP	Integrated Monitor and Control Panel
INT	Intercom (channel)
I/O	Input/Output
IOU	Input/Output Unit
IPS	Inches per Second; Instrument Pointing Subsystem
IRIG	Interrange Instrumentation Group

IS	Interconnecting Station
ITSW	Internal Status Word
IUS	Interim Upper Stage
JSC	Johnson Space Center
KB	Keyboard
KBD	Keyboard Display
kb/s	Kilobits Per Second
kHz	Kilohertz
KUSP	Ku-Band Signal Processor
LED	Light Emitting Diode
LSB	Least Significant Bit
LSU	Loudspeaker Unit
Mb/s	Megabits Per Second
MCC	Mission Control Center
MDM	Multiplexer/Demultiplexer
MET	Mission Elapsed Time
MHz	Megahertz
MMC	Martin Marietta Corporation
MMDB	Master Measurement Data Base
MMU	Mass Memory Unit
MOC	Mission Operations Computer
MSB	Most Significant Bit
msec, ms	Millisecond
MSS	Multispectral Scanner
MSU	Measurement and Stimuli Unit
MTU	Master Time Unit
MUX	Multiplexer
NASA	National Aeronautics and Space Administration
NFOV	Narrow Field of View (MSS)
NIP	Network Interface Processor
NRZ	Nonreturn to Zero
NRZ-L	Nonreturn to Zero - Level Defined
NRZ-S	Nonreturn to Zero - Space
OD	Operational Downlink

OFT	Orbital Flight Test
OI	Operations Interface; Operational Instrumentation
O/P	Output
PB-1	NASA Standard Parallel Binary One Time Code
PBI	Pushbutton Indicator
PCM	Pulse Code Modulation
PCMMU	Pulse Code Modulation Master Unit
PDI	Payload Data Interleaver
PLR	Payload Recorder
PM	Phase Modulation
POCC	Payload Operations Control Center
POD	Payload Operations Division (JSC)
PROM	Programmable Read Only Memory
PS	Power Supply; with number, Power Saving Mode 0 thru 2
PTT	Push to Talk
QM	Qualification Model
RAAB	Remote Amplifier and Advisory Box
RAM	Random Access Memory
RAU	Remote Acquisition Unit
RIW	Record Identification Word
SAR	Synthetic Aperture Radar
SBR	Subroutine Logic
SCOS	Subsystem Computer Operating System
SDL	Software Development Laboratory
SL	Spacelab
SPL	Scratch Pad Line
S/S	Subsystem
SSC	Subsystem Computer
SSPC	Spacelab Stored Program Commands
STDN	Spaceflight Tracking and Data Network
STS	Space Transportation System
S/W	Software

TA	Task Agreement
TBD	To Be Determined
TBS	To Be Supplied
TDM	Time Division Multiplexed
TDRS	Tracking Data Relay Satellite
TDRSS	Tracking Data Relay Satellite System
TLC	Telecommand
TPC	Telemetry Preprocessing Computer
TTL	Transistor-to-Transistor Logic
μs	Microsecond
UT	Unit Tester
UTC	User Time Clock
VCO	Voltage Controlled Oscillator
VOX	Voice Operated Transmission
WER	Word Error Rate
WFOV	Wide Field of View (FSS)
WUI	Western Union International
XCT	Execute

C.1 FUNCTIONAL CONCEPT

The RAU's are the principal interfaces for the bidirectional link between experiments and the CDMS for acquisition of low bit rate digital data, analog data and distribution of commands. The data exchange between RAU's and the I/O unit is performed via simplex serial buses with 1 Mb/s clock rate. The data are encoded in a self-clocking biphase code (Manchester II). Each experiment RAU incorporates the following user interfaces:

A. Inputs

- 128 flexible differential inputs for analog or discrete signals
- 4 serial PCM data channels with associated clocks, code NRZ-L.

B. Output

- 64 ON/OFF command channels
- 4 serial PCM command channels with associated clocks, code NRZ-L
- 4 User Time Clock channels (1024 kHz)
- 4 User Time Clock Update channels, 4 pulse cycles/s.

A block diagram of the RAU is given in figure C-1. It should be noted that the measuring points shown are for bench testing only.

The RAU data acquisition is based on a software controlled concept. The software for subsystem data acquisition and control is provided by Spacelab. The software for experiment data acquisition and control has to be provided by the experimenter in accordance with his requirements. Applicable portions of the Spacelab software can be used by the experimenter.

The RAU's will be scanned periodically with basic periods of 10 ms, 100 ms, or 1 second. Each scan cycle will be initiated and controlled by the GML which is part of the Spacelab computer software. The experimenters may design their own software to generate additional measurement cycles using the operating system task scheduler. This scheduler will accept priority levels and queue up experiment software requests for data and command transmission.

C.2 PHYSICAL CONCEPT

Thirty-two different addresses are foreseen for the RAU's on a bus. The address for a particular RAU is determined by a patch connector. For electrical reasons the buses (S/S and experiment bus) are split into two branches, causing a split of the 32 RAU addresses on each bus.

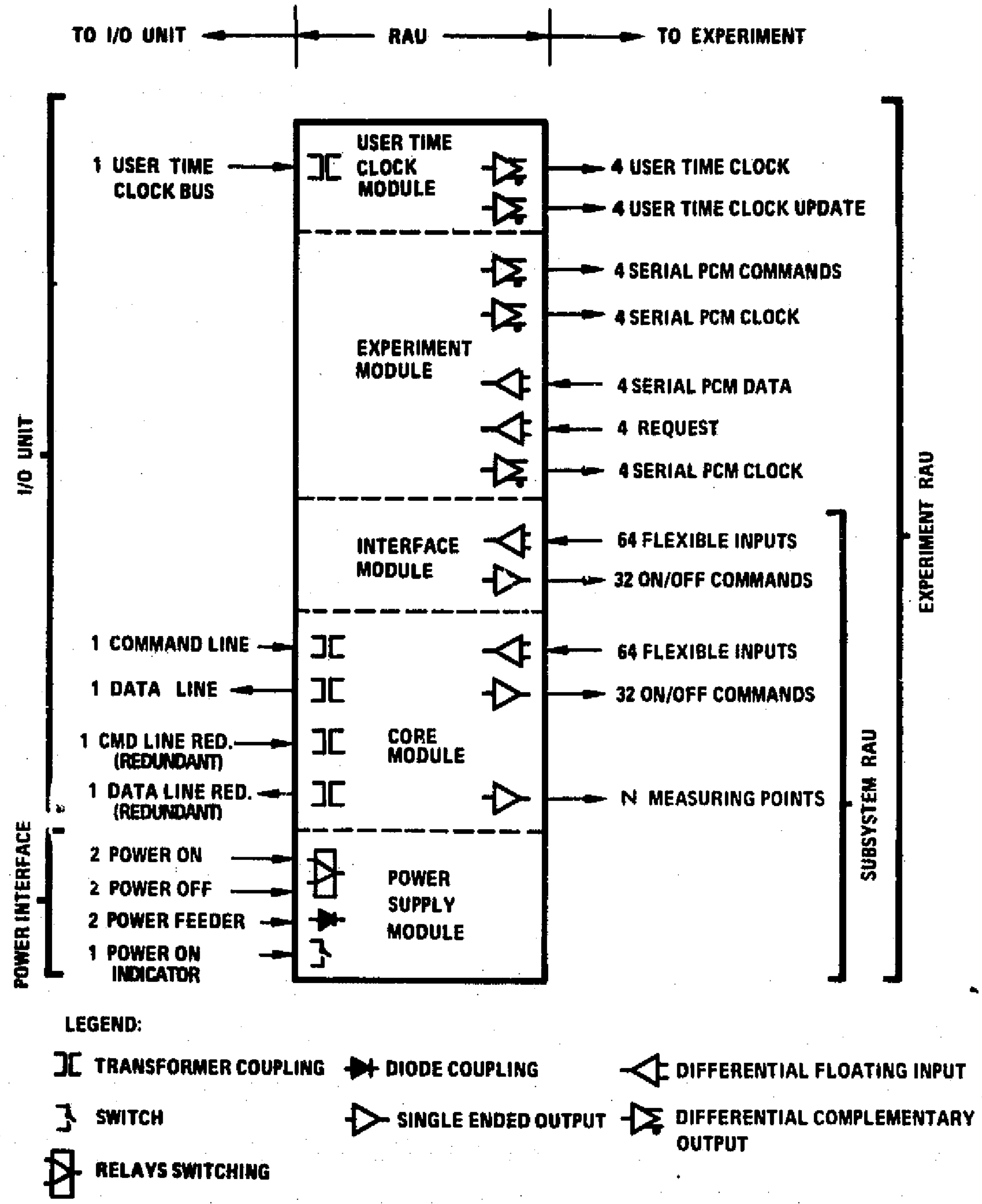


Figure C-1 RAU Block Diagram

The split is for the S/S bus is:

- AFD branch, addresses 0-7 (including IPS S/S RAU's)
- Main branch, addresses 8-31.

The split for the experiment bus is:

- Airlock branch, addresses 0-7 (including IPS experiment RAU's)
- Main branch, addresses 8-31.

The electrical characteristics of the buses allow the accommodation of up to 22 RAU's per branch. Eight experiment RAU's is the total number of units delivered by the Spacelab program.

Experiment RAU's can be connected to the experiment data bus at a number of interconnecting stations (IS's) in the module and on each pallet. There are two interconnecting stations in the core segment, three in the experiment segment, and two on each pallet segment. Each station accommodates two RAU's.

The Spacelab baseline provides standard locations for RAU's in the lower part of the experiment racks. However, the concept allows the user to integrate RAU's together with his experiment equipment, if he uses his own racks and/or experiment equipment mounted directly to the center aisle or to the pallet. In every case the user has to ensure that the cable length between RAU and IS is less than 5 meters, and that the applicable interface specifications of the RAU are met in accordance with EQ-MA-0003.

There are two different types of RAU. The smaller type is the subsystem RAU consisting of the power supply module, core module, and the interface module (see figure C-1). The larger type is the experiment RAU consisting of the subsystem RAU modules plus the experiment module (which provides serial PCM input and outputs) and the User Time Clock (UTC) module. The functions of the RAU are described in the subsequent paragraphs. Figure C-2 depicts the physical characteristics of the experiment RAU.

C.3 RAU - EXPERIMENT LINKS

The RAU-experiment links are depicted in figure C-1.

C.3.1 <u>Data from RAU to Experiments</u>

A. Serial PCM Command Channel. Four RAU channels can deliver serial PCM commands to the experiments, in connection with four RAU provided 1 MHz clock pulses. The code is NRZ-L. The maximum command exchange per

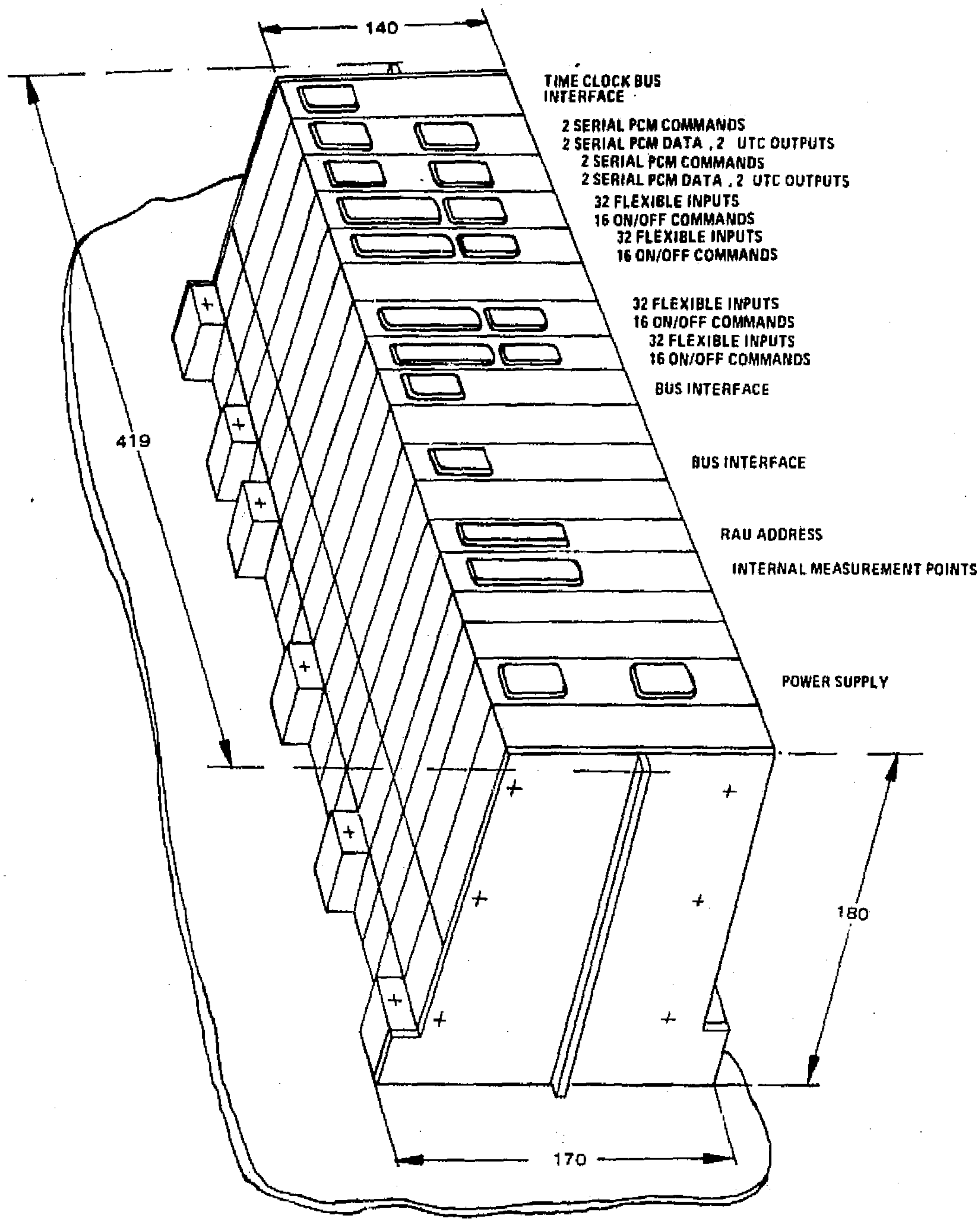


Figure C-2 Experiment RAU Physical Characteristics software requested transaction will be thirty-two 16-bit-words (plus parity bit). The time gap between each two transmitted words will be 3 μs. In addition to commands to control experiment functions, the user may receive via this link additional software generated information such as GMT, MET, ground data, Orbiter state vector, etc.

B. ON/OFF Commands. Each RAU will provide 64 ON/OFF commands as constant voltage levels to the experiments. These outputs may be used to set or reset experiment functions. Each ON/OFF command output has to be individually addressed by the computer software. The load capability of these RAU outputs is designed to drive opto-couplers directly.

C. User Time Clock Outputs. The experimenter can receive timing information from the RAU UTC module. A 1024 kHz clock (duty cycle 0.5) and an update pulse group (every 250 ms) are available. These signals are derived from the master oscillator in the Orbiter MTU and are therefore synchronized with GMT within the accuracies of the count-down electronics chains of the Orbiter MTU.

C.3.2 Data from Experiment to RAU

A. Serial PCM Data Channel. Four RAU channels are available to transfer NRZ-L coded serial PCM data from experiments via RAU to the computer. Each channel consists of a data line, a clock line, and a request line. The RAU will accept from the experiment 17 bit words, including a user generated parity bit as long as the user provides a logic one level on the request line. However, an internal timer in the RAU will restrict the number of serial data words accepted to a maximum of 32. If the request line level changes from one to zero during the transmission of a word, all 17 bits of this word will be accepted by the RAU and transmitted to the computer. Each serial PCM data channel will provide the user with a 1 MHz clock signal to read out the data contained in the experiment buffers. With appropriate software it is feasible to announce the request for serial PCM data by an ON/OFF command to the experiments. NOTE: The parity bit is assigned to a value that makes the number of ones in each 17-bit word an odd number. The status (one or zero) of the experiment provided serial PCM data request lines may be scanned by the RAU on a special software request and transferred to the experiment computer. In this special case the four request lines will be handled like discretes.

B. Flexible Inputs. The experiment RAU provides 128 flexible inputs. The electrically identical differential inputs can be programmed to accept either:

- Discrete input signals (i.e., one bit of parallel digital data)
- Analog input signals which are digitized in the RAU.

The use of flexible inputs as analog or discrete channels is determined by the actual software request (i.e., in principle each flexible input may be changed from analog to discrete or vice versa between two subsequent software acquisition commands). However, in the case of discrete data acquisition only, blocks of 16 inputs are addressable. Thus 16 bits in parallel are accepted and, after addition of one parity bit in the RAU, they are serially transferred to the computer via the I/O unit. The number of 16-bit blocks accepted during one scan cycle is software controlled and may vary from 1 to 8. In the case of analog data acquisition, two adjacent input channels (analog single mode) or blocks of 16 input channels (analog scanning mode) are addressable. The selection of the acquisition mode is software controlled.

The analog/digital conversion has a resolution of 8 bits; thus the conversion of signals in two adjacent input channels leads to a 16-bit word. This word, after addition of one parity bit, is sent via the serial data bus to the I/O unit. In the analog scanning mode up to 64 words per software request can be transmitted to the I/O unit. The analog/digital conversion in the RAU has the following characteristics:

- Full scale voltage range: -5.12 V to +5.08 V
- Resolution (full scale voltage range): 8 bits (7 bits + sign)
- Output code: binary, two's complement, MSB transmitted first (see table C-1)
- Common mode input voltage range: ±6 V
- Operating temperature range (RAU specification): +10° C to +50°C
- Quantization error: ±20 mV maximum
- Non-linearity: ±10 mV maximum
- Temperature coefficient: 50 ppm/°C maximum (10 ppm/°C typical)
- Common mode rejection ratio: > 40 dB between 0 and 500 Hz (special value)
- Overall accuracy: 0.6 percent of full scale ±1/2 LSB (assuming ±1 V common mode voltage).

TABLE C-1

CODING OF THE RAU ADC

Input Voltage Range (V)	ADC Output Bit Pattern							
	Sign	B 7	B 6	B 5	B 4	B 3	B 2	B 1 = LSB
$+5.08 < U \leq +10$	0	1	1	1	1	1	1	1
$+5.04 < U \leq +5.08$	0	1	1	1	1	1	1	0
$+5.00 < U \leq +5.04$	0	1	1	1	1	1	0	1
$+0.08 < U \leq +0.12$	0	0	0	0	0	0	1	0
$+0.04 < U \leq +0.08$	0	0	0	0	0	0	0	1
$0.00 < U \leq +0.04$	0	0	0	0	0	0	0	0
$-0.04 < U \leq 0.00$	1	1	1	1	1	1	1	1
$-0.08 < U \leq -0.04$	1	1	1	1	1	1	1	0
$-0.12 < U \leq -0.08$	1	1	1	1	1	1	0	1
$-5.04 < U \leq -5.08$	1	0	0	0	0	0	0	1
$-5.08 < U \leq -5.12$	1	0	0	0	0	0	0	0
$-10 < U \leq -5.12$	1	0	0	0	0	0	0	0

C.4 I/O UNIT - RAU LINK

The experiment RAU's are linked to the I/O unit by the experiment bus. The data bus consists of a simplex command line which carries instructions and data from the I/O unit to the RAU's and a simplex data line which carries responses and data from RAU's back to the I/O unit. The data bus and the interfaces at the I/O unit and the RAU's are dual redundant. Instructions and data are transferred at 1 Mb/s in 16-bit plus parity words in Manchester II (Biphase-level) code. Each word is preceded by a 3 μs nonvalid Manchester synchronization signal.

An additional "clock bus" is also provided which distributes the MTU derived 1024 kHz clock and update pulses from the I/O unit to experiment RAU's for the user. The data bus and the RAU/bus interface is dual redundant.

The subsystem bus connecting the subsystem RAU's to the subsystem I/O unit is similar to the experiment bus except that the "clock bus" is not provided.

C.4.1 Command Transfer

A. Serial PCM Commands. The serial PCM command transfer from the I/O unit to the RAU is depicted in figure C-3. The transfer will start with a sync pattern and an instruction word followed by the inverted sync and the inverted instruction word. The instruction word includes RAU address, operation code, and channel address as sketched in figure C-4. After the acceptance of this message the RAU will send back an acknowledgment sync to the I/O unit (time delay < 10 μs). The I/O unit now starts the transmission of command information as 16 bits + parity data words as a block with a maximum of 32 words per transaction. Each word is preceded by an inverted sync pattern and the end of the block is indicated by a noninverted sync (EOT).

   The RAU will check the received data words by checking the sync, the Manchester code pattern, and the parity while transmitting them to the experiments. In the case of an error, the RAU will shut down its output immediately. Otherwise it will send back an acknowledgment sync to the I/O unit after receiving the EOT sync (time delay < 5 μs).

B. ON/OFF Command. The ON/OFF command transfer from the I/O unit via the RAU to the experiments is depicted in figure C-5. The transfer will start with a sync signal and an instruction word followed by the inverted sync and the inverted instruction word. The instruction word is depicted in figure C-5 and contains the RAU address, operation code, one bit indicating the level to which the ON/OFF output of the RAU has to be set, and the binary coded channel address. Figure C-5 shows both an ON and an OFF command, i.e., the ninth time the first instruction word

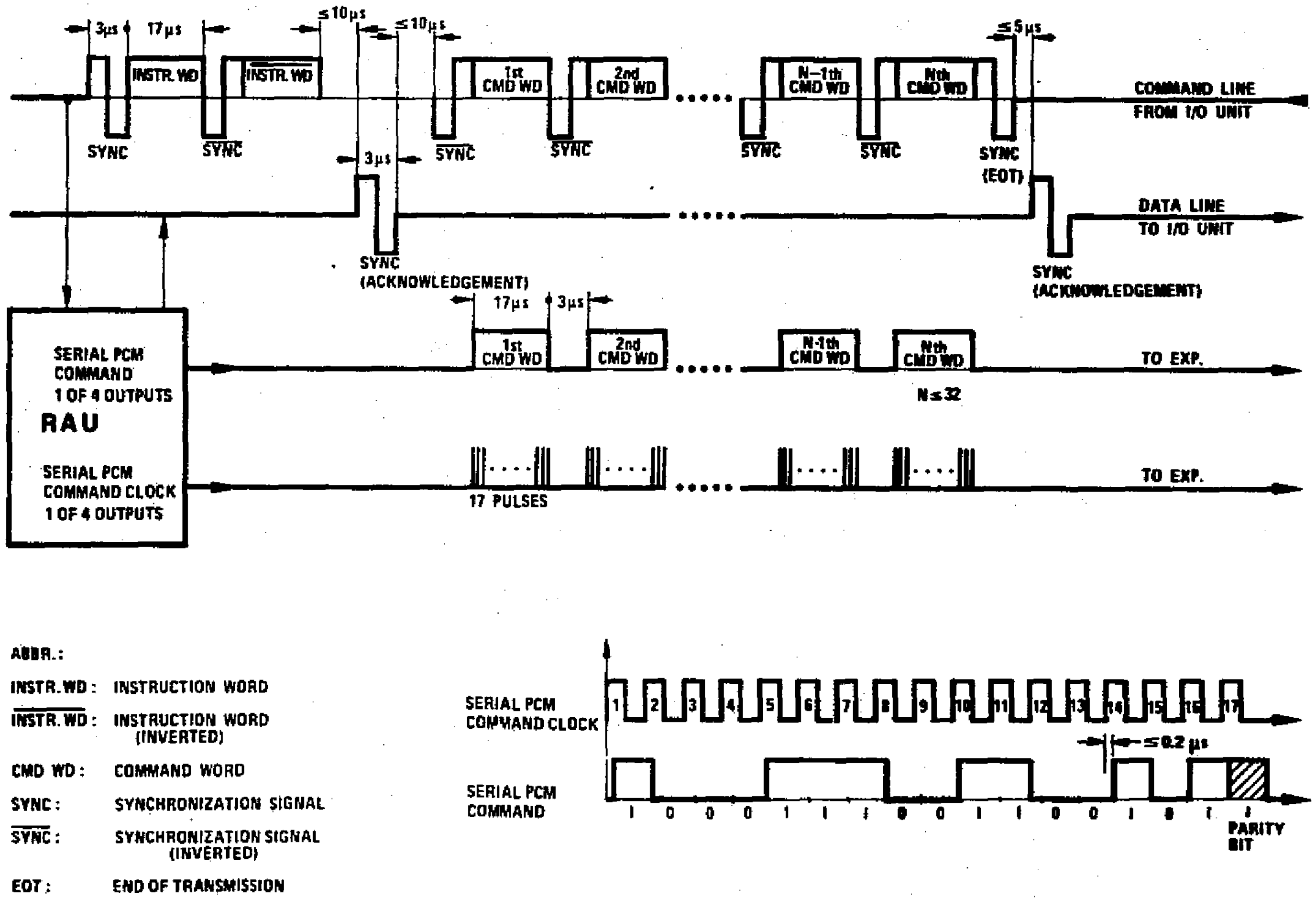


Figure C-3 Timing Diagram for Serial PCM Command Transfer

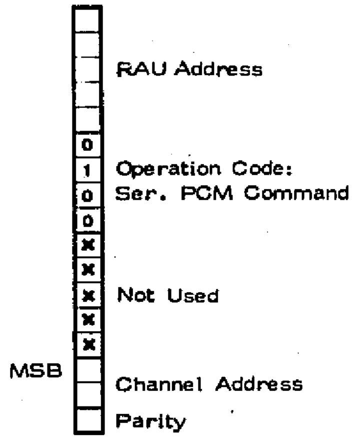


Figure C-4 Instruction Word Serial PCM Command

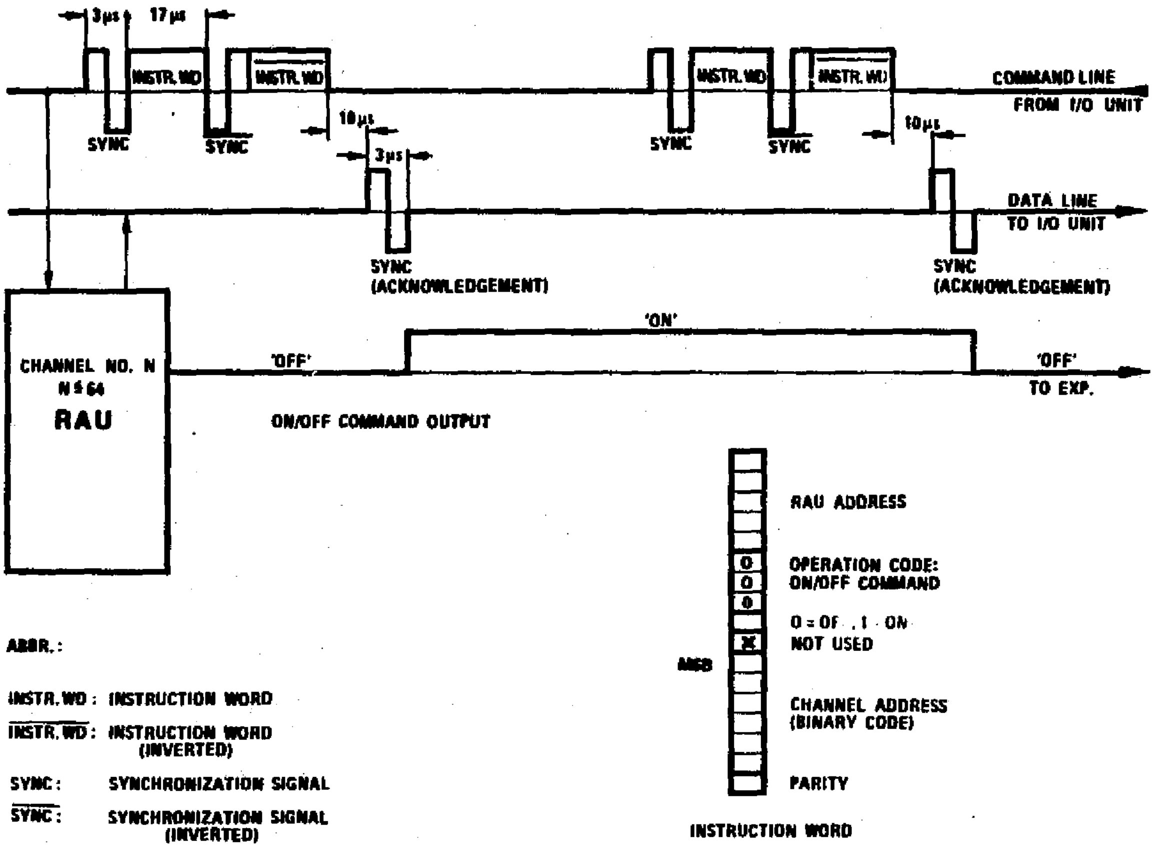


Figure C-5 ON/OFF Command Transfer

contains a 1 while this bit in the second instruction word is set to 0. The validity of the instruction word is checked as described for serial PCM commands. If no errors are detected, the RAU will send back an acknowledgment sync to the I/O unit; otherwise, the status of the command channel will remain unchanged.

C.4.2 Data Transfer

A. Serial PCM Data Inputs. The transfer of serial PCM data from an experiment via RAU to the I/O unit will be initiated by a software generated instruction word on the command line (figure C-6). The structure of the instruction word is also given in figure C-6. After receiving this word, the RAU will check the status of the request line of the addressed serial PCM data channel. If the status of the request line is detected as zero, the RAU will send back a sync signal to the I/O unit within a maximum time delay of 10 μs. In this case, the computer system will stop the dialogue for this channel or repeat the transfer of instruction words as determined by software. If the status of the request line is detected as one, the RAU will start to deliver clock pulses to the experiment within a time < 2.5 μs. These clock pulses are grouped in blocks of 17 pulses and separated by a 3-μs time gap. Each block will take 17 μs and will be used to read out one 17-bit word from the experiment buffer. (The 17th bit always has to be the experiment-generated parity bit.) The RAU will continue to deliver these clock pulses as long as the status of the request line is one, the number of words transmitted from the experiment to the RAU is not greater than 32, and no parity error is detected in the user's data words.

The data words received by the RAU will be processed and transmitted to the I/O unit in real time. Processing includes a check of each parity bit, conversion from NRZ-L to Manchester II (Biphase-level) code, and the generation of sync signals at the beginning of each data word and at the end of the data transfer.

As depicted in figure C-7, there exists another possibility to scan the status of the RAU request lines for serial PCM data inputs. The request line scan may be of advantage for experiments using several RAU input channels for serial PCM data with randomly distributed acquisition times. The dialogue between I/O unit and RAU for scanning the request line status of four channels of one RAU will take a maximum of 53 μs, while the data acquisition mode described above will need at least 132 μs to check four channels with request lines having zero status.

The dialogue will start with a sync signal and an instruction word transmitted by the I/O unit on the command line. The structure of this instruction word is shown in figure C-7. After a maximum time delay of 10 μs, the RAU will answer with a data word as shown in figure C-7, preceded by an inverted sync signal and followed by a sync signal. Four bits of this data word (one for each channel) will contain the status of the request lines.

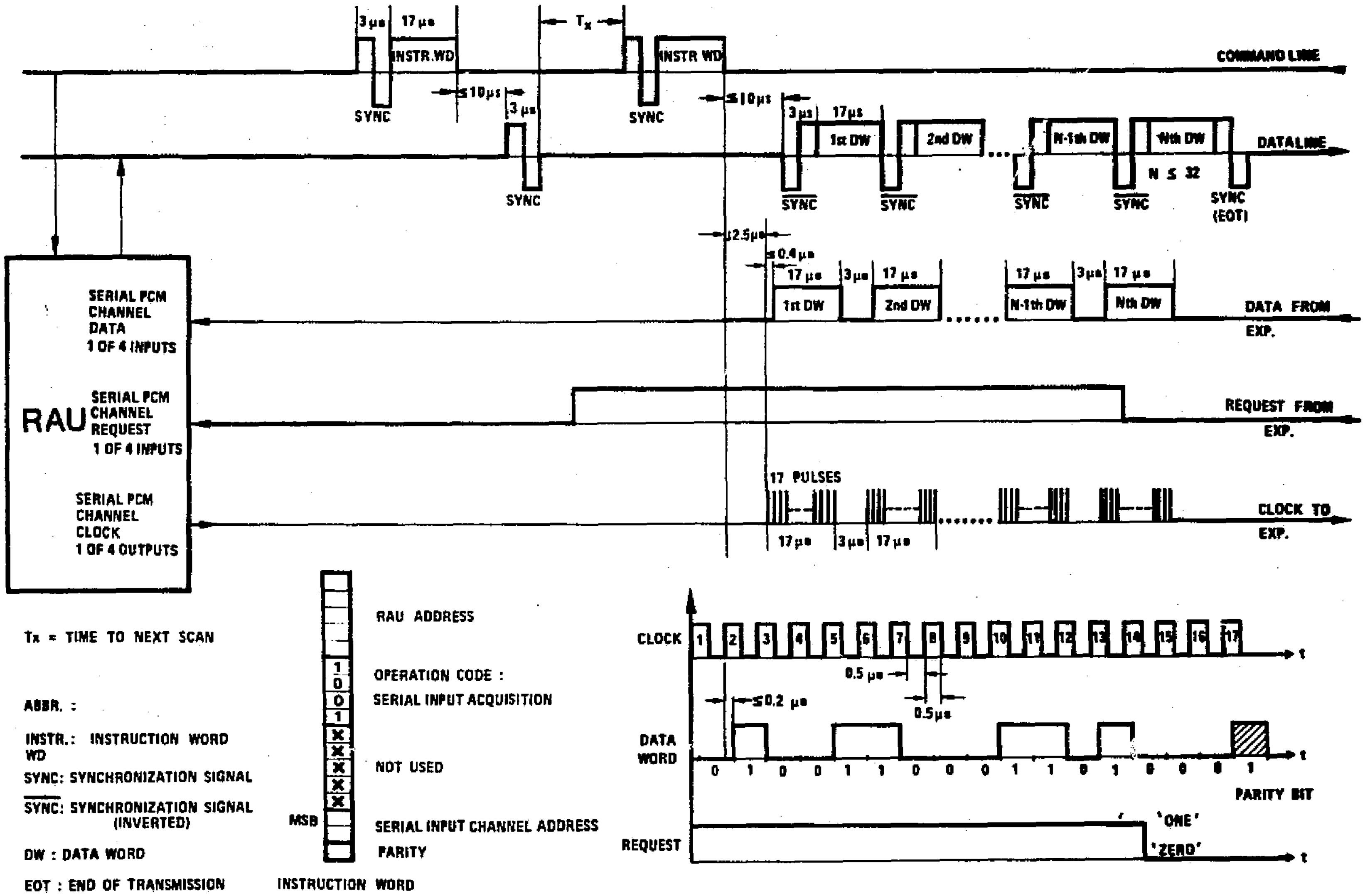


Figure C-6 Timing Diagram for Serial PCM Data Transfer

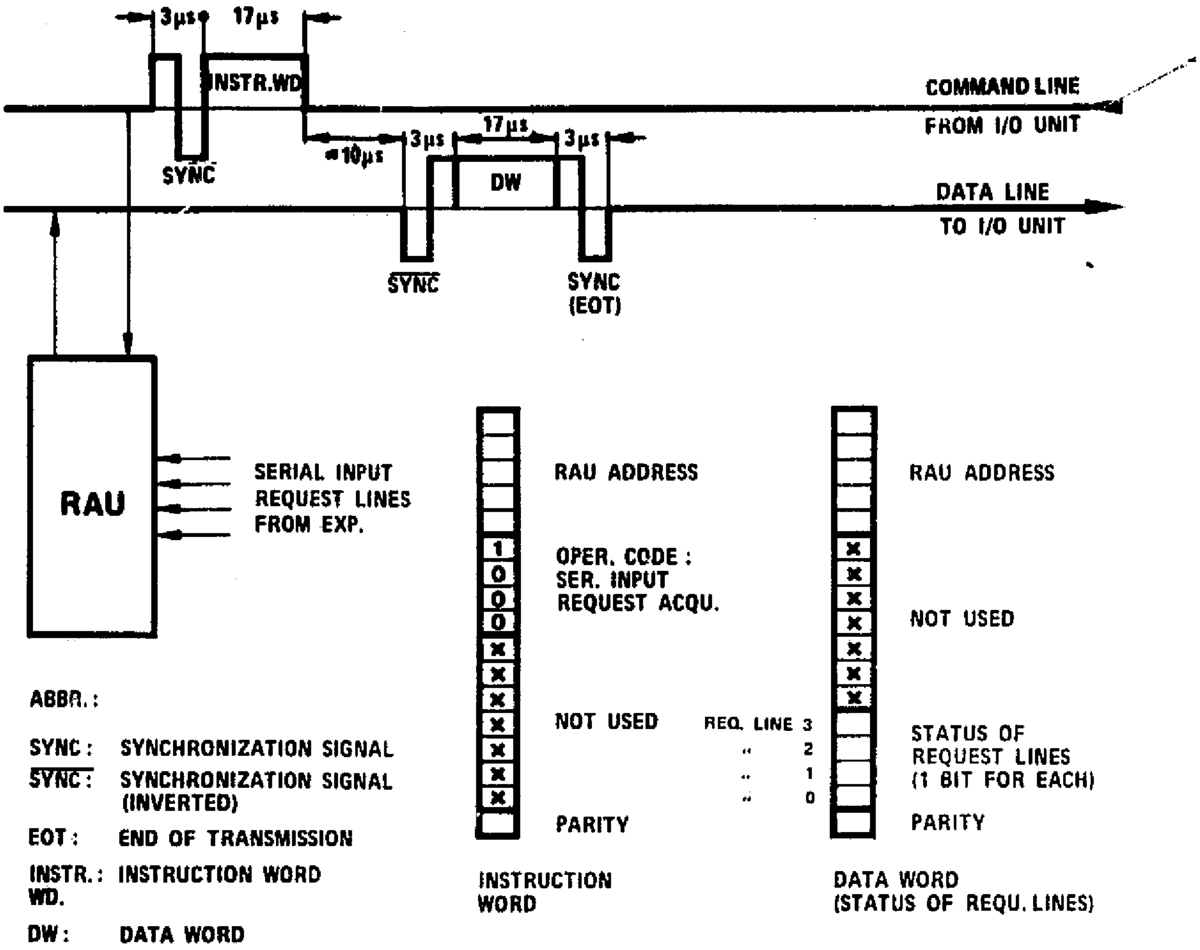


Figure C-7 Transfer of Serial PCM Data Request Line Status

B. Flexible Inputs. The acquisition of analog signals (analog mode) as well as parallel digital data (discrete mode) is performed via the flexible inputs.

1. Analog Data. The acquisition of analog data is depicted in figure C-8. The instruction word includes RAU address, RAU channel or block address, and operation code. Included in the operation code is the information to acquire analog data and the sampling mode as shown in figure C-8. Two modes are possible:

   a. Analog Single Mode. This mode allows the sampling of two adjacent channels. The binary RAU channel address in the instruction word has to be even and may be in the range from 0 to 126. The digitized analog signal of the addressed channel and the next following one will be transmitted to the I/O unit.

   b. Analog Scanning Mode. This mode samples blocks of 16 input channels. The number of blocks acquired per software request is determined by the user and may vary from 1 to 8. This information is contained in the instruction word in an N of 8 code.

   Each block address is directly correlated to 16 flexible hardware inputs. The correlation between hardware inputs and software channel and block addresses cannot be changed by the user. After receiving the instruction word, the RAU initializes the 8-bit analog/digital conversion. The digitized signals of two input channels form a 16-bit word. The RAU adds a parity bit, encodes the word, and starts the transfer to the I/O unit less than 20 μs after receiving the instruction word. As the analog/digital conversion circuitry consists of two sample and hold units and a fast ADC, there will be no time delay in addition to the transmission time determined by the RAU-I/O unit dialogue.

2. Discrete Data. The acquisition of discretes is depicted in figure C-9. The dialogue starts with a software-generated instruction word which is sent on the command line to the RAU. The instruction word contains RAU address, operation code, and the block address in an N of 8 code. The smallest unit which may be sampled is a block of 16 discrete inputs transferred as 16 bits plus a parity bit per word via the data line to the I/O unit. The number of blocks transmitted per software request may range from 1 to 8. The correlation between software block address and pin allocation of the RAU cannot be changed by the user. The transfer between RAU and I/O unit is completed by an RAU-generated sync on the data line.

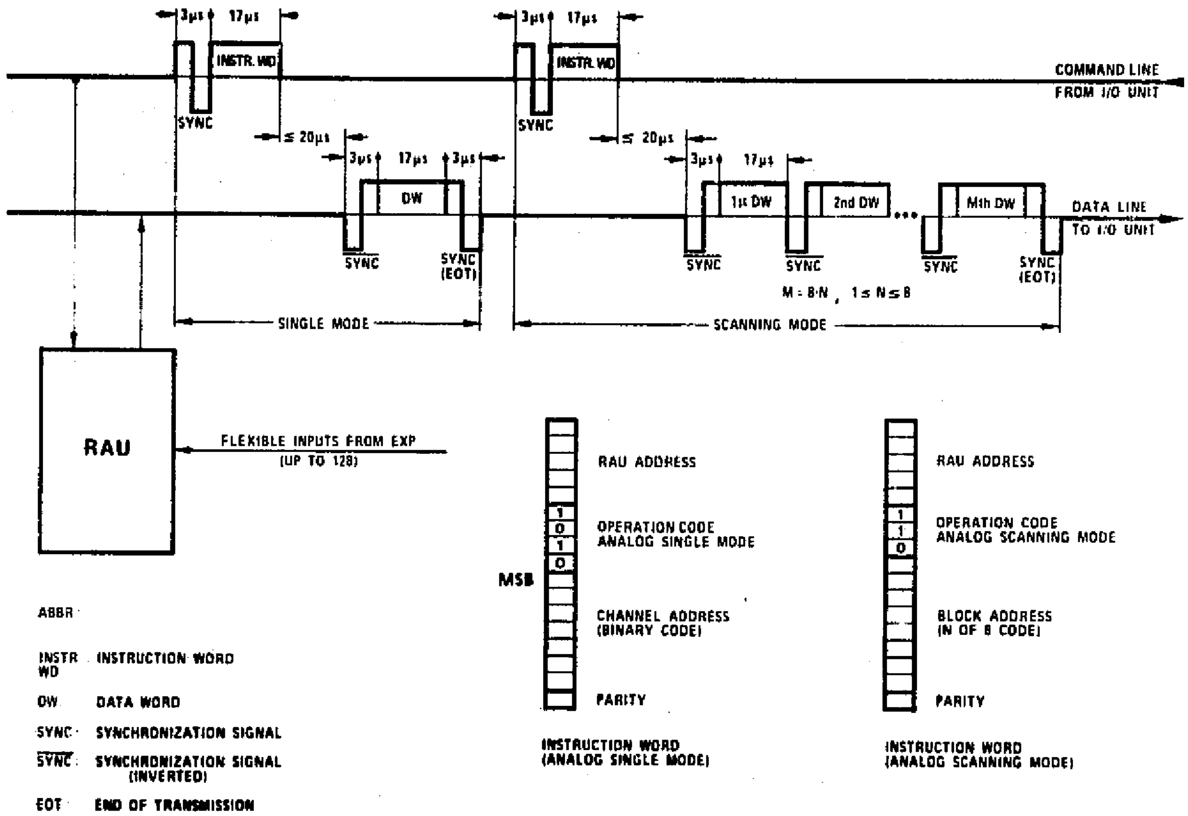


Figure C-8 Acquisition of Analog Signals via Flexible Inputs

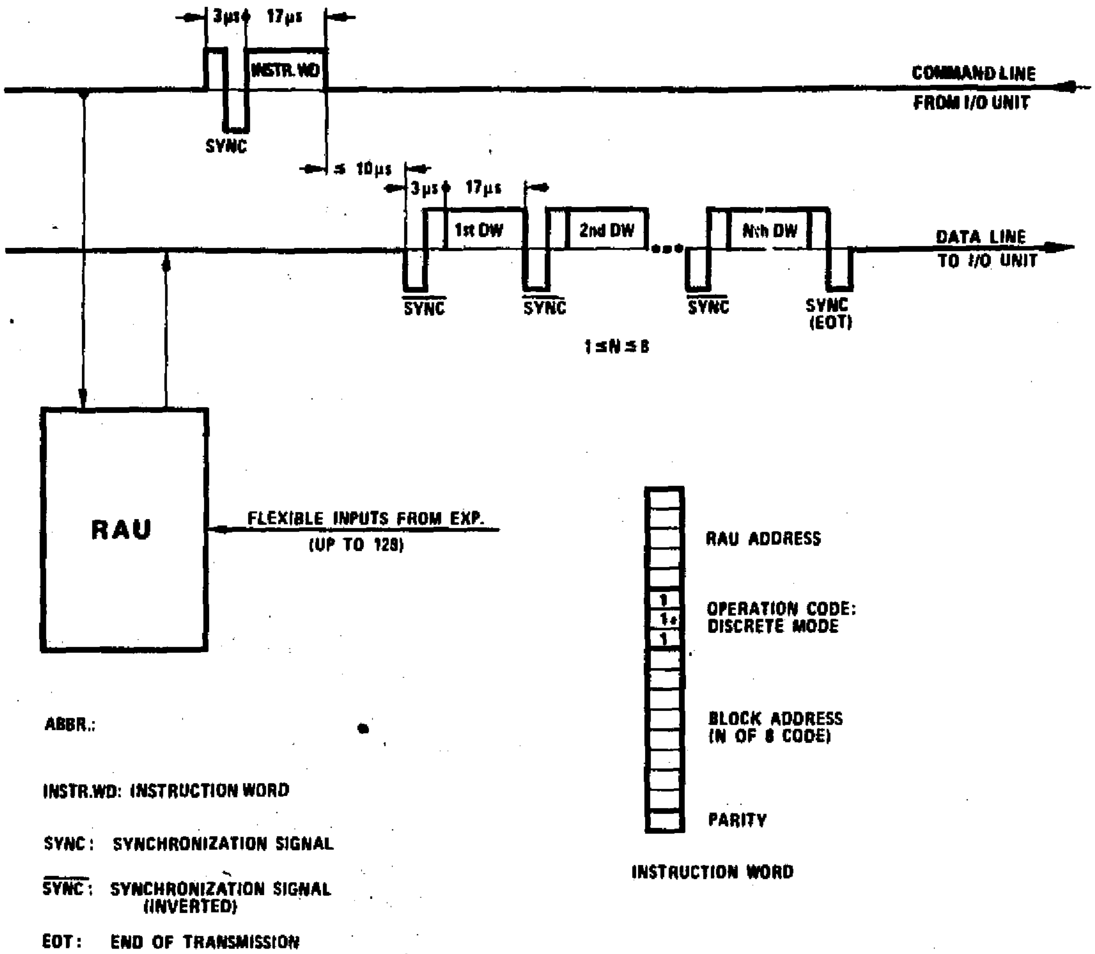


Figure C-9 Acquisition of Discretes via Flexible Inputs

C.4.3 RAU Test Modes. The RAU is designed to check the performance of the received data. This applies to the instruction and data words from the I/O unit and the serial data words from the experiment. In addition, the I/O unit will check the data words from the RAU.

Data and instruction words from the I/O unit and RAU data words sent to the I/O unit have to fulfill the following criteria:

- Word transmission at 1 Mb/s bit rate
- Manchester II coding properties
- Each word must consist of a sync (or $\overline{\text{sync}}$) + 16 data bits + parity bit
- Valid operation code (applicable to instruction words only)
- Odd parity of each word.

If a word does not fulfill one of these criteria, the word is considered invalid and will not be accepted by the receiving unit. In particular, the RAU will stop its work and the error will be indicated in the RAU internal status word (see figure C-10) by bit No. 12, which is set to logical level one. In addition, the RAU will not send back to the I/O unit an acknowledge sync signal (see figures C-3 and C-5) or and end of transmission signal (see figures C-6, C-7, and C-8).

After the error has been detected, the I/O unit (or more precisely the RAU-coupler of the I/O unit) repeats either the whole sequence, if the failure is related to ON/OFF commands or acquisition of data via flexible inputs, or the instruction words only, if the failure is related to serial PCM commands or serial PCM data acquisition.

If the repetition has no success, the RAU-coupler of the I/O unit will initiate a self test. The RAU internal status word (as depicted in figure C-10) will be acquired by the I/O unit. The results will be analyzed to decide whether to switch over to the redundant part of the experiment CDMS data bus (including the redundant bus interface units) or to switch off the RAU.

Experiment data words at the RAU input will be checked only with respect to the experiment-generated odd parity bit. If a parity error is detected, the RAU will stop sending bit shift pulses to the experiment. In addition, no end of transmission (EOT) sync (see figure C-6) will be sent back to the I/O unit, and bit No. 11 of the RAU internal status word (see figure C-10) is set to level one. In contrast to the traffic on the data bus, there is no automatic self test related to parity errors in the experimenters data; therefore, the user should acquire this status word periodically by his own request.

C-3

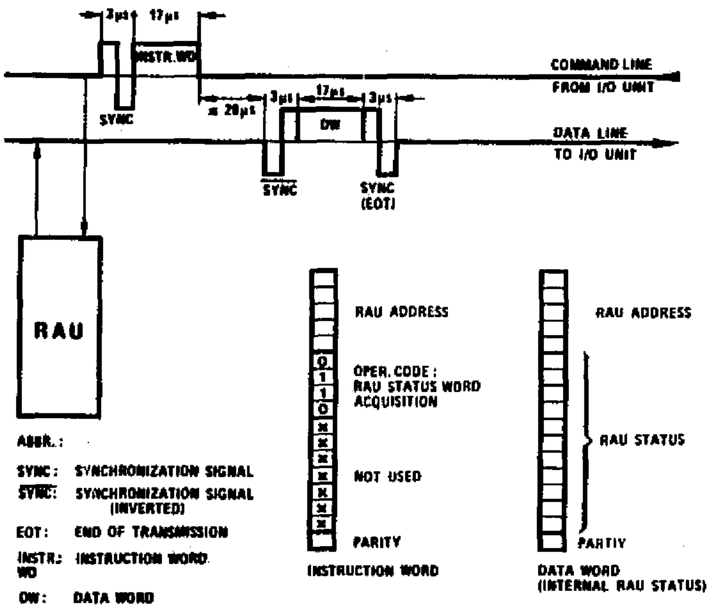


Figure C-10 RAU Internal Status Word Acquisition

A more detailed test, including a check of the RAU analog-to-digital converter, is depicted in figure C-11 and will be performed only on user's request.

RAU internal status word acquisition is as follows. The dialogue (figure C-10) starts with an instruction word on the command line. Whithin less than 20 μs, the RAU will return a data word containing the following.

A. Bits 0-4. This is the RAU address.

B. Bit 5, Primary Power Breakdown. The primary power voltage will be checked for under-voltage below 24 V during a period longer than 500 μs. The bit 5 will be set to one when the primary power recovers the normal range. This bit will be reset to zero by the acquisition of the internal status word, and will keep this state if no voltage drop occurs. If no failure occurs, bit 5 will show one level for the first internal status acquisition, and always zero for the following acquisitions.

C. Bit 6, UTC Status. This bit will be set to one in the case of complete or momentary absence of UTC signal coming from the I/O unit. This bit will be reset to zero after internal status word acquisition.

D. Bit 7, Experiment Module ON/OFF Status. This bit is set to one if the RAU experiment module is powered.

E. Bit 8, Interface Module Correction Status. This bit is set to one if the RAU interface module is physically connected and powered.

F. Bit 9, ON/OFF Command Status of the Core Module. This bit, set to one, will indicate that the ON/OFF command boards in the core module are energized.

G. Bit 10. This bit, set to one, will indicate that the ON/OFF command boards of the interface module are energized.

H. Bit 11, Serial PCM Input Channel Status. This bit is set to one if, on any of the four serial input channels of the RAU, the serial PCM clock is not working properly, the user words show wrong parity, or the nominal time for transferring 32 user data words has elapsed (timeout). This bit is reset to zero after each acquisition of the status word.

I. Bit 12, I/O Unit - RAU Data Link Status. This bit is set to one if the RAU detects an error in the serial data incoming from the I/O unit. After each acquisition of the status word, the bit is reset to zero.

J. Bits 13-15. Spares.

The RAU test command initiates the RAU BITE cycle. This mode provides more detailed information about the status of the RAU including the previously mentioned internal status word. The dialogue is depicted in figure C-11.

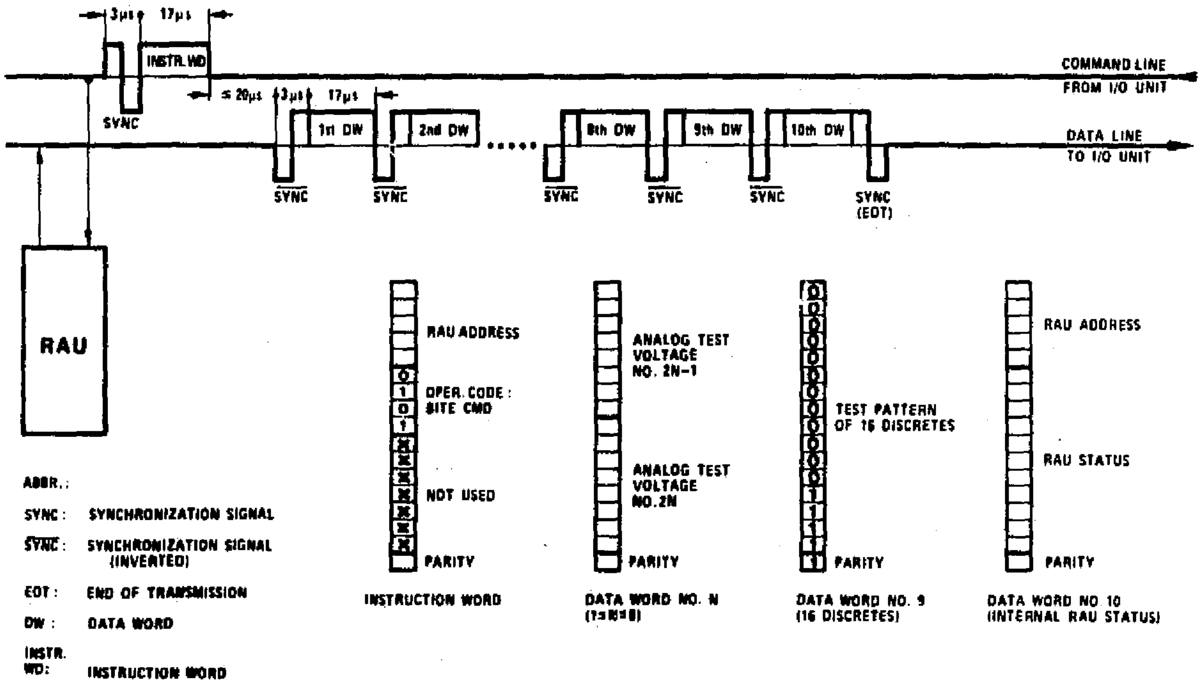


Figure C-11 RAU Test Cycle

E.1 GENERAL

The PCMMU is an interface device between the Orbiter GPC and the Spacelab subsystem and experiment computers. Reference 6 defines this interface. The GPC can access Spacelab data from the PCMMU for performance monitoring and backup caution and warning processing. Selected mission phase dependent data will be passed to the ground station for maintenance and mission support. The PCMMU has access to a specified block of memory in the subsystem and experiment computers. The experiment computer must support the PCMMU by placing data into the memory locations at predefined rates.

E.2 PCMMU OPERATION

The PCMMU contains a fetch command sequence and a random access memory (RAM) for storing the fetched data. During a mission (prelaunch through landing), the sequence of fetch commands issued by the PCMMU for the transfer of data from a specific Spacelab memory locations to a specific RAM location shall be absolutely fixed. The PCMMU shall accept 16-bit words at a rate of up to 64 kb/s. The data is moved from the PCMMU RAM, combined with the Orbiter PCM data, and transmitted to the ground as part of the Orbiter's PCM telemetry data.

The PCMMU master frame fetch cycle is 1 second. The PCMMU accesses data across the data bus from the Spacelab subsystem and experiment computers every 500 μs via the PCMMU fetch command sequence. Each of 2000 fetch commands is issued in sequence from 1 to 2000 over every 1-second interval. Each PCMMU fetch command can access up to ten 16-bit words from the Spacelab subsystem and experiment computers. Data requests alternate every 500 μs between the subsystem computer and the experiment computer, with the subsystem computer always accessed first. The PCMMU fetch commands can sample the Spacelab computer's data at rates dictated by the PCMMU format.

A BITE status request (BSR) fetch command shall be issued to each Spacelab input/output unit once each PCMMU master frame fetch cycle. The BSR will occur in the same place in the fetch command sequence every cycle. Receipt of the BSR by the Spacelab input/output unit shall always initiate a BITE request response.

The information signals will be transferred over the data bus in serial-digital pulse code modulation form in Manchester II Bi-Phase Level Code. Data shall be transferred at a 1 Mb/s rate. The fetch command shall consist of 24 data bits plus sync and parity. Each response message shall be in the form of data words, with each word consisting of 24 data bits plus sync and parity. The sync word shall be a nonvalid Manchester Code.

The fetch command word format is given in table E-1. The dump OP code is used to request the return of data from the computer memory. The memory address is the address relative to the PCMMU buffer start address. The PCMMU coupler is initialized with the PCMMU buffer start address. The memory address and number of words are irrelevant when the Return Command and Return BITE Status Word OP Codes are used.

The response data word format is given in table E-2. The state of the error bit (bit 26) is determined by the input/output coupler.

TABLE E-1

FETCH COMMAND WORD

BIT	DESCRIPTION
1-3	COMMAND SYNC - THREE BIT NONVALID MANCHESTER CODE
4-8	SPACELAB ADDRESS - FIVE BIT CODE WHICH IDENTIFIES THE SPACELAB I/O THAT SHALL RESPOND TO THE COMMAND SUBSYSTEM I/O = 10000, EXPERIMENT = 11000
9-11	OPERATIONAL CODE - 010 RETURN COMMAND 110 RETURN BITE STATUS WORD 100 DUMP
12-22	MEMORY ADDRESS - MEMORY ADDRESS OF FIRST DATA WORD IN THE RESPONSE MESSAGE (0-1999)
23-27	NUMBER OF WORDS - FIVE BIT CODE THAT IDENTIFIES THE NUMBER OF DATA WORDS TO BE TRANSMITTED. THE SPACELAB SHALL TRANSMIT WORDS FROM A CHANNEL ADDRESS INCREASING MONOTONICALLY STARTING AT THE CHANNEL ADDRESS 00000 = 1 01001 = 10
28	PARITY - ODD PARITY

TABLE E-2

RESPONSE DATA WORD

BIT	DESCRIPTION
1-3	DATA SYNC - THREE BIT NONVALID MANCHESTER CODE
4-8	SPACELAB I/O ADDRESS - FIVE BIT CODE THAT IDENTIFIES THE SPACELAB I/O RESPONDING TO THE COMMAND WORD, IDENTICAL TO BITS 4-8 OF THE FETCH COMMAND WORD
9-24	DATA - CONTAINS THE REQUESTED DATA, BITE DATA, OR RETURN COMMAND DATA. BIT 9 IS THE MOST SIGNIFICANT BIT
25	FIXED AT "1" FOR ALL WORDS
26	ERROR - INDICATES DETECTION OF INTERNAL SPACELAB ERROR CONDITIONS ASSOCIATED WITH THE ACQUISITION AND HANDLING OF THIS DATA WORD
27	FIXED AT "1" FOR ALL WORDS
28	PARITY - ODD PARITY

E.3 EXPERIMENT COMPUTER SUPPORT OF THE PCMMU

A PCMMU fetch command will be received by the experiment input/output unit every millisecond. The command may request 1 to 10 data words, the BITE status word, or the return of the command word. Data from the same memory location may be requested at rates dictated by the PCMMU format. The fetch command sequence will be repeated every second. To support the fetch command sequence, the experiment computer shall place the appropriate data into the memory locations that are being fetched.

The length of the PCMMU buffer required in the experiment computer is dependent on the fetch command sequence. The fetch command sequence should be determined by the number of parameters to be fetched and their desired fetch rates. The PCMMU buffer will be divided into three sections: synchronous data, operating system variable data, and application programs variable data. The lengths of each section is mission-dependent.

A BITE status request (BSR) will be received once a second. The storing of data into the PCMMU buffer shall be synced to the BSR. Since the location of the BSR is fixed within the fetch sequence and the parameters to be transmitted are known, buffer locations can be assigned to each parameter prior to each mission. This will ensure that the locations will not be written into at the time the data is fetched and that the fetched data is current. The parameters to be fetched and their fetch rates are mission-dependent. All data accessed by the Orbiter shall be in fixed locations within the PCMMU buffer.

E.4 SYNCHRONOUS DATA

The synchronous data portion of the buffer will be used for the transmission of synchronously sampled data. Data collected for PCMMU transmission via the general measurement loop (GML) must be placed in this portion of the buffer. Experiment computer data may also be in this section of the buffer. No processing shall be performed on the data.

The first word transmitted in the fetch cycle must be a code identifying the start of PCMMU cycle. The second word transmitted in the fetch cycle must be a code identifying the PCMMU mode. The PCMMU modes shall correspond to the GML modes of data collecting. The number of modes and the format of the codes identifying the modes are mission-dependent. The start of PCMMU cycle code must be a binary 1111000011110000.

E.5 APPLICATION PROGRAMS VARIABLE DATA

A section of the PCMMU buffer that is fetched once per second must be reserved for data requested by application programs. The length of this section of the buffer is mission-dependent. The application must request the ECOS to transmit the data and indicate the number of words to be transmitted. The ECOS must affix a code identifying the application, and a word indicating the number of words to be transmitted. The ECOS must schedule the loading of the data into the PCMMU buffer so that all the data words will be transmitted to the same cycle. Any additional identification coding within the data words is the responsibility of the application program. Memory dump will be one of the application programs that will use this section of the buffer.

E.6 OPERATING SYSTEM VARIABLE DATA

A portion of the buffer that is fetched once per second must be reserved for operating system variable data. This data includes error messages, two-stage buffer commands, keyboard entries, displayed data, and general log information. Since the generation of this data is not synchronized with the PCMMU fetch sequence, and in most cases a block of data must be transmitted as a unit, temporary buffers will be required for the data. The data in the temporary buffers shall be loaded into the PCMMU buffer once per second. Since the location of the BSR in the fetch sequence is fixed, the interrupt caused by the BSR can be used to schedule the transfer of the data from the temporary buffers into the PCMMU buffer so that this section of the buffer is not being loaded while the data is being fetched. The number of memory locations in the PCMMU buffer that must be reserved for the operating system variable data is mission-dependent. The data must be loaded into the PCMMU buffer with the following priority: error messages, two-stage commands, keyboard entries, displayed data, and general log. The two-stage buffer will never have more than one entry, but the other buffers may have multiple entries. No partial entries in the temporary buffers shall be loaded into the PCMMU buffer.

Each entry in the PCMMU buffer must be preceded by a header word. The header word format is given in paragraph A below. Paragraph B below defines the data description code in the header word. The header word must contain a data description code which identifies the type of data, and a binary number indicating the number of words within the entry including the header word. The number of words indicator for the end of valid buffer code must be all zeros.

A. <u>Header Word Format</u>

- Bits 1-5, Data Description Code

- Bits 6-16, Number of words.

B. Data Description Code. The code configurations and corresponding data definitions are as follows:

- 10001, Error Messages
- 10010, Two-Stage Buffer
- 10011, Keyboard Entry
- 10100, Displayed Data
- 10101, General Log
- 11011, End of Valid Buffer.

E.7 MINIMUM SET OF ASYNCHRONOUS DOWNLINK DATA

The following parameters are the minimum set of asynchronous data the SSC is to output to the PCMMU for downlink. However, this requirement can be met if the parameters are acquired by the GML.

1. Hardware-Associated Items

   a. Normal Exchange Inputs

      (1) S/S IOU RAU coupler ITSW.

      (2) S/S IOU DDS coupler ITSW.

      (3) S/S IOU PCMMU coupler ITSW.

      (4) S/S IOU MDM coupler ITSW.

      (5) S/S IOU TIME coupler ITSW.

      (6) S/S IOU MMU coupler ITSW.

      (7) S/S IOU RAU coupler ERSW.

      (8) S/S IOU DDS coupler ERSW.

      (9) S/S IOU PCMMU coupler ERSW.

      (10) S/S IOU MDM coupler ERSW.

      (11) S/S IOU TIME coupler ERSW.

      (12) S/S IOU MMU coupler ERSW.

      (13) Exp IOU RAU coupler ITSW.

      (14) Exp IOU DDS coupler ITSW.

      (15) Exp IOU PCMMU coupler ITSW.

      (16) Exp IOU MDM coupler ITSW.

      (17) Exp IOU TIME coupler ITSW.

      (18) Exp IOU MMU coupler ITSW.

      (19) Exp IOU RAU coupler ERSW.

(20) Exp IOU DDS coupler ERSW.

(21) Exp IOU PCMMU coupler ERSW.

(22) Exp IOU MDM coupler ERSW.

(23) Exp IOU TIME coupler ERSW.

(24) Exp IOU MMU coupler.

(25) S/S (BU) Computer Program mode error word.

(26) Exp (BU) computer program mode error word.

b. Functional Test Inputs

(1) MMU status register A.

(2) MMU status register B.

(3) Each S/S RAU (8) has the following:

- Internal status word
- Digital Test word
- Analog test word Nos. 1-8.

(4) Each Exp RAU (32) has the following

- Internal status word
- Digital test word
- Analog test word Nos. 1-8.

(5) S/S IOU coupler (6) functional test results.

(6) Exp IOU coupler (6) functional test results.

(7) S/S PCMMU link test word(s).

(8) Exp PCMMU link test word(s).

(9) S/S MDM link test word(s).

(10) Exp MDM link test word(s).

(11) S/S MMU link test word(s).

(12) Exp MMU link test word(s).

c. Monitoring Point Inputs

(1) Each S/S RAU (8) has the following:

- BIU status
- S/S secondary voltage.

(2) Each Exp RAU (32) has the following:

- BIU status
- S/S secondary voltage.

(3) Each DDU/KBD (3) has the following:

- 16 MHz clock (normal/abnormal)
- Deflection test
- Occupancy (busy)
- KBD blocking
- All keystrokes (SPL)
- All system messages displayed
- All application program messages displayed
- Page I/D being viewed.

(4) S/S IOU undervoltage.

(5) S/S IOU secondary current.

(6) Exp IOU Undervoltage.

(7) Exp IOU secondary current.

d. Miscellaneous

(1) S/S main memory dump.

(2) Exp main memory dump.

(3) Mass memory unit dump.

(4) Transmission (I/O) errors in data received from ground.

2. Software-Associated Items

a. Software Error Processing

(1) CDMS mode switch indicator (software to hardware).

(2) Results of I/O error processing routines.

(3) I/O error accumulator (for retries that worked).

(4) Computer self-test for SCOS, interpreters, and applications.

b. Software Status

(1) Checksum verification of loads.

(2) Priority interrupts assigned.

(3) Interrupts inhibited (and by whom).

(4) Number of programs executing concurrently.

(5) Stack (queue) status.

(6) Name of program executing.

(7) Time program started.

(8) Time program ended.

(9) Reason terminated (normal/abnormal).

(10) Status of program:

- Hold
- Retest
- Executing.

(11) All commands issued by an application program.

(12) All pages applicable to each application program.

(13) Next location in main memory available for an application program load.

(14) High rate MUX status (at 1 S/S).

- Current format ID
- Audio channel MUX status
- Input overflow status
- Temperature
- Power supply status/voltages
- Power saving status
- BIU errors
- Load parity errors
- BITE status monitoring.

(15) IPS - TBD.

(16) Read/write status

- Address
- Data current
- Data desired (loaded)
- Mode
- Bit set/reset
- Sequence.

(17) SPC buffers (10 commands with GMT).

(18) MMU tape status.

(19) HDRR status - [time remaining on tape (assumes remainder of data on GML)].

(20) GMT of last checkpoint.

(21) Orbiter state vector (if processed by Spacelab S/W).

(22) Uplink buffer for data.

(23) Computer (internal) GMT and MET.

(24) Location (address) of where each program is loaded relative to beginning of load area.

(25) Core available for loading (number of available registers).

APPENDIX H

COMMAND AND DATA MANAGEMENT SYSTEM ASSESSMENT
(SL1 EXPERIMENT DATA REQUIREMENTS)

This appendix contains the whole of section 9, Command and Data Management System, of the *Preliminary MSFC Spacelab Mission 1 Integrated Payload Requirements Document*, dated 21 October 1977. It is a summary of all Spacelab 1 experiment data requirements, and an assessment of those requirements against the CDMS capability of Spacelab.

9.0 COMMAND AND DATA MANAGEMENT SYSTEM

9.1 INTRODUCTION

Data presented in this section is a summary of all Spacelab 1 experiment data requirements, and an assessment of these requirements against the Spacelab CDMS capabilities. The experiment requirements as summarized reflect the latest information that was exchanged during the ESA and NASA ERD reviews during August-September 1977. The assessment of these requirements against the Spacelab CDMS capabilities was performed by ESA/SPICE with its ECOS/GSOC study team and MSFC Data Systems Laboratory personnel. Considered were requirements against the Experiment Computer, and its associated peripherals, and the High Rate Data Acquisition System.

While the study of the control and management of the experiment data from the Spacelab payload must inevitably consider both the airborne and ground operations, this study is primarily devoted to evaluating the airborne experiment requirements because the CDMS configuration is a function of experiment requirements. However, since continuous ground coverage will not be available for Spacelab, it was necessary to evaluate the data flow requirements for realtime and post mission operation.

9.2 OVERVIEW

9.2.1 Objectives

The primary objective of the study was to support the Spacelab Integrated Payload Requirement Review, and to specifically:

a. Assess the Spacelab 1 experiment requirements against the baseline capability for adequacy.

b. Assign experiments to CDMS resources.

c. Define constraints and ground rules.

d. Identify Mission Peculiar Equipment (MPE).

e. Identify problems and propose solutions.

f. Provide recommendations for future activities.

9.2.2 Approach

The approach selected was to compile all experiment requirements into a composite set and to define, by experiment, the required CDMS interfaces. After which, an analysis of these requirements against all elements of the Orbiter/Spacelab data was conducted. Of prime consideration were the loads on the Experiment Computer, and bus the High Rate Multiplexer (HRM), the High Data Rate Recorder (HDRR), and the Analog/Video system.

To determine the experiment/timeline compatibility, the timeline was examined to determine which experiments will operate together over specific time intervals. With this information, along with the experiment interface assignments to the CDMS, a detailed analysis of the load on the Experiment Computer data bus was made. For each time interval the data rates to the Experiment Computer were determined.

Similarily, the timeline was examined to determine the maximum data rates into the HRM, and the output of the HRM was evaluated against the TDRS coverage for compatibility. Also, video and analog requirements were considered as inputs into the Ku-Band Signal Processor in a similar fashion.

After determining the maximum data rates into the CDMS, a detailed analysis of the composite digital data rates into the Ku-Band signal processor was made. Considered in this analysis were, TDRSS coverage, recorder dump requirements and the functional objectives of each experiment. The capability to conduct an automated analysis of the analog/video-digital mix versus the timeline has not reached full maturity. However, a hand analysis of a selected portion of the timeline during high analog/video activity was conducted.

9.2.3 Assumptions/Groundrules

The following assumptions/groundrules were used in support of this study:

a. Utilize the Module layout dated October 5, 1977, and the Pallet layout dated September 28, 1977, for the purpose of assigning interfaces to the CDMS.

b. Consider the timeline dated August 28, 1977, for the data flow analysis.

c. VFI will be controlled by the Experiment Computer and operates continuously throughout the mission.

d. The minimum sampling rate for experiments is one sample per second.

e. All data will be transmitted to the ground, except for some select onboard processed data.

f. Low rate data ($\leq$5KBPS) will be transmitted via the Experiment Computer I/O-High Rate Multiplexer (HRM) link. High rate data will be routed directly to the HRM.

g. Data allocated to the PCMMU will be considered a subset of the data allocated to the Experiment Computer I/O - HRM link.

h. Only software requirements to support acquisition of "raw" telemetry data were considered.

i. Sun and horizon sensors will interface to the CDMS.

Specific assumptions/groundrules for the CDMS appear in the appropriate sections.

9.2.4 Progress

During the ERD reviews it was possible, through direct discussions with the Principal Investigators, to avoid many incompatibilities. With these discussions, it was possible to achieve a mutual understanding of the experiments and their requirements on the data system to meet their scientific objectives. In many cases requirements were reduced as a result. In particular, the requirements for 100 samples per second were minimized. The net result was a projected load on the Experiment Computer that fits well within the baseline capability, and sufficient growth margin.

All electrical interfaces, except caution and warning, have been identified.

The CDMS guidelines have been updated consistent with the maturity of the design and understanding of the CDMS hardware and software capabilities.

Computer programs, developed by the Data Systems Laboratory, were utilized to assign CDMS resources, i.e., Remote Acquisition Unit (RAU), as aids to evaluate the Experiment Computer data bus, and to evaluate the composite data flow versus GET.

An analysis of HRM formats could not be conducted to the same level of detail as the evaluation of the load on the data bus. However, maximum loads on the HRM were evaluated and no serious problems were identified. A detailed analysis of the HRM formats will be a natural follow-on exercise, utilizing the results of this study and an updated timeline.

Since this was the first joint attempt at a detailed analysis of the CDMS requirements for Spacelab 1 the experience and design aids gained will be invaluable for future integration studies for Spacelab 1 and subsequent missions.

9.3 REQUIREMENTS SUMMARY

The CDMS requirements are summarized, by experiment, in Tables 9.3.1. - 9.3.3. Depicted are:

a. The location of the experiment

b. HRM requirements

c. Analog/video requirement

d. RAU requirements

Detailed experiment requirements are summarized in Appendices A, B, and C.

SPACELAB 1 CDMS REQUIREMENTS SUMMARY

M = MODULE ◣ = ASSUMED
P = PALLET

TABLE 9.1

EXPERIMENT	NUMBER	LOCATION	HRM	ANALOG	VIDEO	RAU: NUMBER	RAU: FLEXIBLE INPUTS: ANALOG	RAU: FLEXIBLE INPUTS: DISCRETE	RAU: PCM DATA	RAU: DISCRETE OUTPUTS	RAU: PCM COMMANDS	RAU: UTC + UTCU
IMAGING SPECTROMETRIC OBSERVATORY	INS001	M / P	1 / –	– / –	– / –	2M / 3P	4 / 22	– / –	1 / –	8 / 40	1 / –	1 / –
SPACE EXPERIMENTS WITH ACCELERATORS	INS002	M / P	1 / –	– / 1	– / 1	2M / 3P	16 / 46	– / –	1 / –	6 / 2	1 / 1	1 / –
ATMOSPHERIC EMISSION PHOTOMETRIC IMAGING (LLTV)	INS003	M	2	–	1	2M	–	–	1	6	1	–
STUDIES OF THE IONIZATION STATUS OF SOLAR AND GALACTIC COSMIC RAY HEAVY NUCELI	INS004	P	–	–	–	3P	1	16	–	18	–	–
FAR UV OBSERVATIONS USING THE FAUST TELESCOPE	INS005	P	–	–	–	3P	13	–	–	13	–	–
HZE PARTICLE DOSIMETRY	INS006	M	–	–	–	–	–	–	–	–	–	–
CHACTERIZATION OF PERSISTING CIRCADIAN RYTHMS	INS007	M	–	–	–	–	–	–	–	–	–	–
ACTIVE CAVITY RADIOMETER SOLAR IRRADIANCE MONITOR	INA008	P	–	–	–	3P	6	–	1	4	1	
ATMOSPHERIC TRACE MOLECULES OBSERVED BY SPECTROSCOPY	INA009	M	2	–	–	1M	16	30	–	–	–	
TRIBOLOGICAL STUDIES OF FLUID LUBRICATED JOURNAL BEARINGS	INT011	M	–	–	–	1M	8	–	1	–	–	
GEOPHYSICAL FLUID FLOW	INT012	M	–	–	–	1M	–	–	–	?	–	–
VERIFICATION FLIGHT TEST	VFI	M / P	2 / 1	– / –	1 / –	1M / –	– / –	20 / –	1 / –	34 / –	– / –	– / –
LIFE SCIENCES–MINILAB	INS100	M	1	–	1	4M	–	–	–	–	–	1

SPACELAB 1 CDMS REQUIREMENTS SUMMARY

M = MODULE
P = PALLET

TABLE 9.2

EXPERIMENT	NUMBER	LOCATION	HRM	ANALOG	VIDEO	RAU						
						NUMBER	FLEXIBLE INPUTS		PCM DATA	DISCRETE OUTPUTS	PCM COMMANDS	UTC + UTCU
							ANALOG	DISCRETE				
GRILLE SPECTROMETER	IES013	M / P	1 / –	– / –	– / –	3M / 2P	4 / 18	2 / 25	1 / –	4 / 12	1 / –	1 / –
WAVES IN OH EMISSIVE LAYER	IES014	P	–	–	–	1P	1	4	–	2	1	1
TEMPERATURE, WIND IN MESOSPHERE THERMOSPHERE	IES015	P	–	–	–	1P	1	1	2	4	1	1
SOLAR SPECTRUM FROM 1990A – 4 MICRON	IES016	P	–	–	–	2P	8	–	1	4	1	1
HAND D LYMAN ALPHA	IES017	P	–	–	–	1P	9	3	1	8	1	1
MAGNETIC FIELD MEASUREMENT	IES018	M	2	–	–	3M	8	–	1	9	1	1
LOW ENERGY ELECTRONS	IES019	P	1	–	–	2P	–	–	2	7	1	1
PHENOMENA INDUCED BY CHARGED PARTICLE BEAMS	IES020	M / P	1 / –	–	–	3–4 M / 2P	– / –	6 / 6	– / –	15 / 1	1 / –	– / –
SOLAR CONSTANT	IES021	P	–	–	–	2P	7	8	1	18	–	–
VERY WIDE FIELD CAMERA	IES022	M	–	–	–	3M	–	–	1	2	1	–
X–RAY SPECTROSCOPY (GAS SCINTCOUNTER)	IES023	P	1	–	–	2P	15	–	1	6	1	1
HEAVY COSMIC RAY ISOTOPES	IES024	P	–	–	–	1P	2	15	–	3	–	–
MASS DISCRIMINATION	IES025	M	–	–	–	–	–	–	–	–	–	–

SPACELAB 1 CDMS REQUIREMENTS SUMMARY

M = MODULE
P = PALLET

TABLE 9.3

EXPERIMENT	NUMBER	LOCATION	HRM	ANALOG	VIDEO	RAU: NUMBER	RAU: FLEXIBLE INPUTS: ANALOG	RAU: FLEXIBLE INPUTS: DISCRETE	RAU: PCM DATA	RAU: DISCRETE OUTPUTS	RAU: PCM COMMANDS	RAU: UTC + UTCU
MEASUREMENT OF INTRATHORAXIC BLOOD PRESSURE	IES026	M	–	–	–	–	–	–	–	–	–	–
ADVANCED BIOSTACK	IES027	M / P	– / –	– / –	– / –	2M / 1P	3 / 3	2 / 2	– / –	2 / 2	– / –	– / –
3-D BALLISTOCARDIOGRAPHY	IES028	M	–	–	–	–	–	–	–	–	–	–
EFFECT OF RADIATION	IES029	P	–	–	–	1P	4	3	–	2	–	–
ELECTROPHYSIOLOGICAL TAPE RECORDER	IES030	M	–	–	–	–	–	–	–	–	–	–
LYMPHOCYTE PROLIFERATION IN WEIGHTLESSNESS	IES031	M	–	–	–	–	–	–	–	–	–	–
COLLECTION OF BLOOD SAMPLES	IES032	M	–	–	–	–	–	–	–	–	–	–
METRIC CAMERA	IEA033	M	–	–	–	2M	16	–	1	3	1	1
MICROWAVE SCATTEROMETER-RADIOMETER	IEA034	M / P	2 / –	– / –	– / –	3M / 2P	– / 5	– / –	1 / 1	10 / 15	1 / 1	
SLED EXPERIMENTS	IES200/201	M	–	–	2	4M	16	2	2	3	1	–
MATERIALS SCIENCE	IES300	M	–	–	–	4M	–	10	1	–	1	1
SUN SENSOR (ASSUMED)	–	P	–	–	–	2P	1	12	–	2	–	–
HORIZON SENSOR (ASSUMED)	–	P	–	–	–	3P	1	–	1	2	–	–

9.4 EXPERIMENT/TIMELINE COMPATIBILITY

9.4.1 Approach

The approach to assessing the experiment complement against the timeline was to assume the timeline of August 28, 1977, to be valid and to use it as a basis of departure. Since available time and personnel were limited for this study, it was necessary to devise a method to reduce the granularity of the data contained within the timeline. The method selected was to examine the timeline and divide it into time segments whenever a relatively large group of experiments could be operating simultaneously. The following assumptions were made for each time segment to produce the "smoothed" timeline:

a. All experiments operating within a time segment will operate continuously over that time interval.

b. The maximum experiment data rate is assumed to be constant over the total time segment.

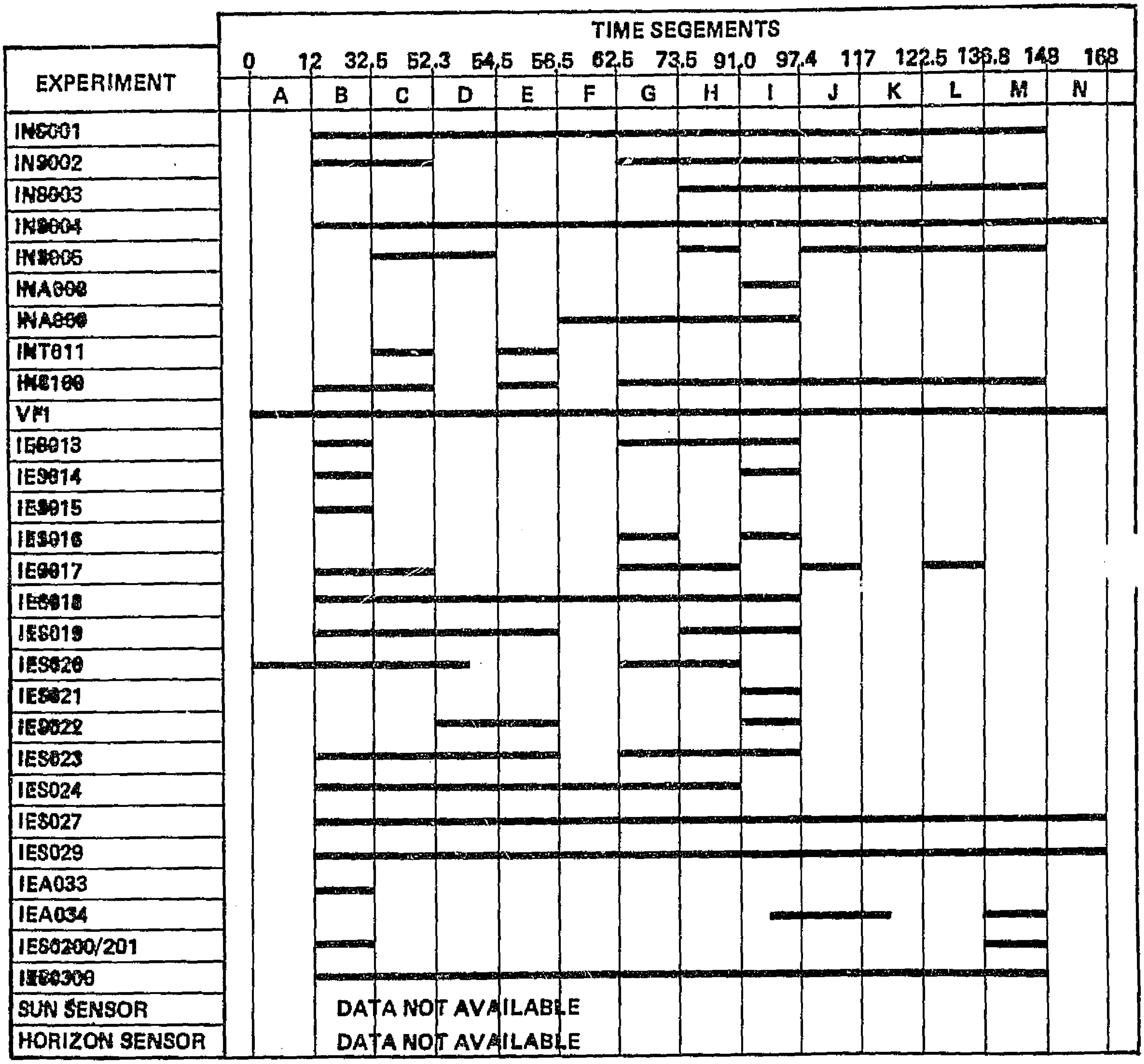
For example: If an experiment operates five time within a one-hour interval and generates 1KBPS for only one of the operations, a one-hour continuous operation at a constant 1KBPS rate was assumed.

9.4.2 Experiment Groups

As can be observed from Figure 9.1, the timeline was eventually divided into 14 parts (A through N). Those experiments operating during a specific time interval were combined to form a group, for example: all experiments operating during time segment E (54.5 - 56.5) were assigned to group E. During each time segment it will be necessary for the Experiment Computer to gather data from each experiment for inclusion into a predefined data format for subsequent transmission to the ground. Each one of these formats is a General Measurement Loop Table (GMLT) that resides in a core memory buffer of the Experiment Computer.

Also, the smoothed timeline was used to project probable maximum loads on the High Rate Multiplexer and the CCTV system for all 14 time segments.

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR



EXPERIMENT OPERATIONS (SMOOTHED) VS GET

FIGURE 9.1

9.5 CONSTRAINTS/GROUNDRULES

The information presented in this section describes the CDMS and its associated components that were considered for the purposes of supporting this study. Listed are the components that were allocated for management and control of the payload.

Also listed, by subsystem, are the constraints/groundrules necessary to support the objectives of this study.

9.5.1 Hardware Resource Allocations

The total CDMS is depicted in Figure 9.2 and the experiment requirements were assessed against its presently understood capability. The following CDMS resources were allocated and any other elements identified as required to accommodate the payload are classified as Mission Peculiar Equipment (MPE):

a. Eight Remote Acquisition Units

- 128 flexible inputs
- 64 on/off commands
- 4 PCM data lines
- 4 PCM command lines
- 4 user time clock
- 4 user time clock update

b. One High Rate Data Acquisition System

- High Rate Multiplexer
  - o 16-16 MBPS inputs
  - o 2 Direct 32 MBPS inputs
  - o 3 Voice inputs
  - o Interconnect to Experiment and Subsystem

Computer busses

CDMS BLOCK DIAGRAM

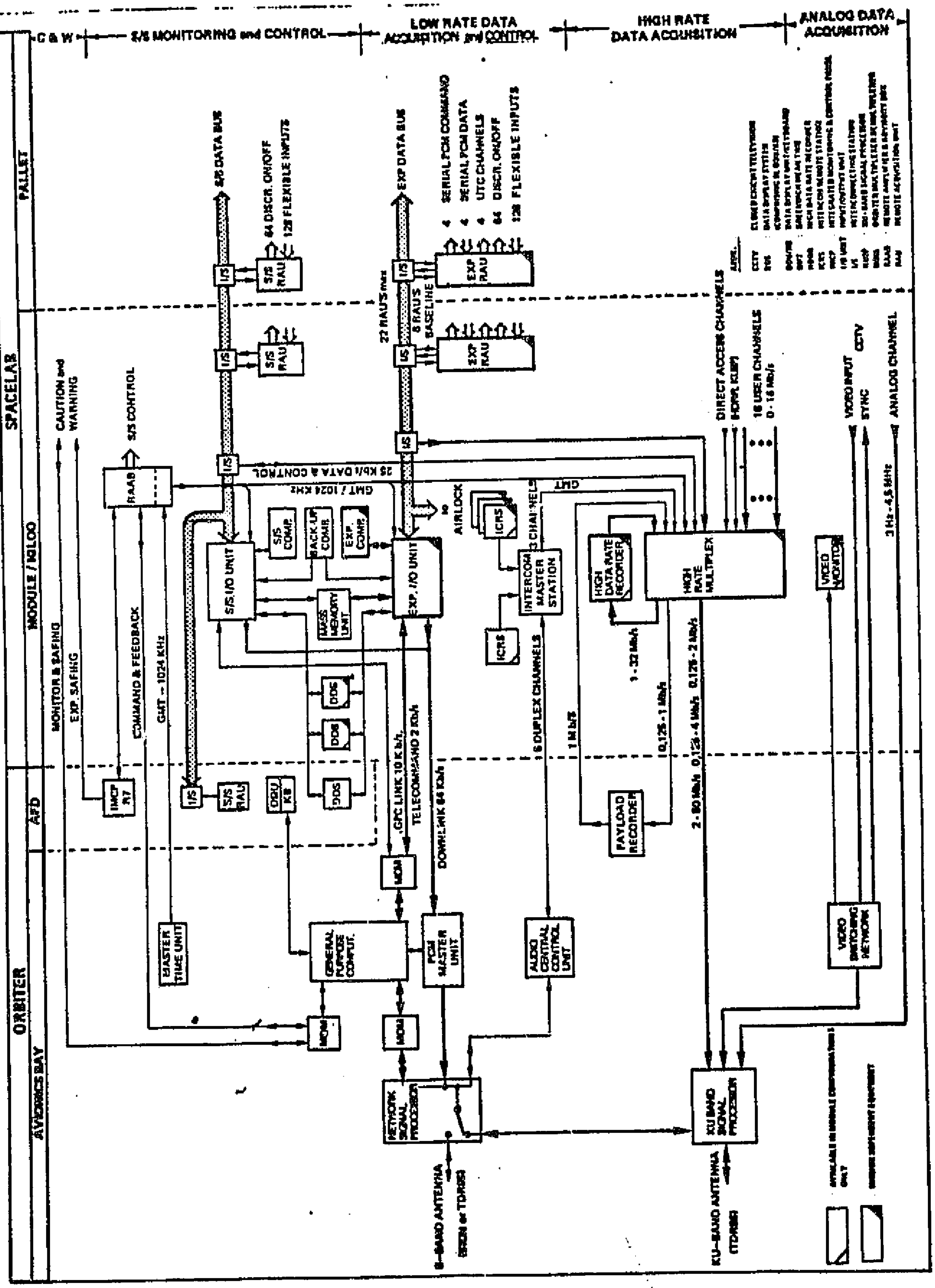


Figure 9.2

- High Data Rate Recorder

  o Maximum input rate 32 MBPS, for data acquisition during TDRSS outages.

c. One TV/Analog Channel

- For onboard CCTV or analog signal (3Hz-4.5MHz)

d. One Experiment Computer with access to the Mass Memory Unit, and three display units (two in Module, one in the AFD).

9.5.2 System

The system constraints on the resources as listed above are listed under either the appropriate CDMS subsystem, the subject under consideration, or the appropriate appendix.

9.5.2.1 General Measurement Loop

a. RAU Assignments

(1) Analog channels with the same sampling rate will be assigned by pairs or in groups of 16 whenever possible.

(2) Discrete channels with the same sampling rate will be assigned in groups of 16 whenever possible.

(3) All experiments will interface to a single RAU whenever possible.

(4) Experiments operating simultaneously should interface to a common RAU(s).

(5) Cable restrictions are undefined, but the cable length and number shall be minimized.

b. The GMLT will remain constant for a given time segment.

c. If a RAU is powered off a new GMLT is required.

d. A GMLT can be activated only on whole seconds.

e. A GMLT is repeated each second.

f. Data bus errors are ignored.

g. All GMLT data will be routed to the HRM except as noted.

9.5.2.2 PCMMU

a. All data samples at 10 S/S or less will be routed to the PCMMU buffer.

b. There are 2000 memory locations for PCMMU downlink.

c. The format is fixed for a given mission.

These groundrules were made in the absence of a definite set of requirements for PCMMU contents to support Orbiter operations.

9.5.2.3 Commands

One RAU command slot will be reserved during each computer minor cycle.

9.5.2.4 High Rate Multiplexer

The following CDMS timeline constraints were provided to be included into the timeline program to assure that data flow is considered along with the other disciplines/concerns for the current Spacelab integration study.

a. The real time composite data rate of simultaneous experiments cannot exceed 48MBPS;composite rates during each loss of signal (LOS) cannot exceed 32 MBPS.

b. During every acquisition of signal (AOS) of 10 or more minutes a maximum of 10 minutes is required for a HDRR dump. During this time the composite digital rates cannot exceed 16MBPS, and no real time transmission of video or analog is allowed, however, video/analog can be recorded for delayed transmission. This number was, by mutual consent with timeline personnel, reduced to three minutes for a HDRR dump.

c. If video or analog is required in real time, the composite data rate cannot exceed 2 MBPS.

d. Only two video/analog signals may be accommodated if there is LOS or the data rate exceeds 2 MBPS.

e. Analog/video data scheduled during non-real time cannot exceed 30 minutes.

f. If video/analog is scheduled during LOS, then dumps must be scheduled prior to the next recording. This requires 30 minutes of real time and a composite data rate of less than 2 MBPS.

9.5.2.5 Video/Analog

The Spacelab module will be equipped to provide, in conjunction with the orbiter CCTV system, the capability to observe, record, and transmit the video and wideband analog signals which will be generated by the various TV cameras and the SEPAC plasma-wave probes. The constraints imposed on the use of the video/analog system are as follows:

a. One video transmission channel to ground is available and must be time-shared. Its use is further constrained by the restriction which it places on the composite digital data rate capability of the Ku-Band signal processor, and the consequent necessity to schedule its use to be compatible with other experiment operations.

b. Permanent tape recording of analog or video data for transport of tapes to ground is not permitted. The primary purpose of the video/analog recorder is to provide data storage capability during inaccessibility of the TDRS link, for later transmission to earth. A secondary purpose for the recorder is to enable the acquisition of two simultaneous video or analog experiment outputs.

c. The maximum recording time for the video/analog recorder is 60 minutes for single-channel recording and 30 minutes for dual-channel recording. Only one channel can be played back at a time.

9.6. CONFIGURATION DEFINITION AND RESOURCE ALLOCATION

Data presented in this section reflects the ability of the CDMS to accommodate the experiment requirements as defined in the most recent ERD review.

Considered are the interfaces to the RAU, HRM, Analog/ Video inputs. Also, an evaluation of the load on the Experiment Computer data bus, the composite data rates versus GET and a format for the data on the Experiment Computer I/O - HRM link are presented.

9.6.1 Remote Acquisition Units

The experiment assignments to RAU's are depicted in Table 9.2 which illustrated the location relative to the Spacelab. Based on the most recent understanding of the CDMS requirements, the allocated experiment RAU's can be reduced from eight to seven (four for the Module and three for the Pallet). The experiments are assigned to the RAU's as indicated and the tables summarize the growth margin. As can be observed, only RAU's 1P and 3P have negative growth margin; two solutions are possible for RAU 3P: (1) Convert these lines to another RAU or (2) work with the PI to decrease the number of discrete commands. Number 2 is the preferred solution and experiment 1NS001 is a probable candidate, since 40 discrete commands are requested and they could be combined into a single serial command stream for execution via a PCM Command. The net result will be a reduction in wires and a reduction in MPE weight.

Two solutions are also possible for RAU 1P. They are:

a. Reduce the number of PCM data channels for experiment IES015 by one.

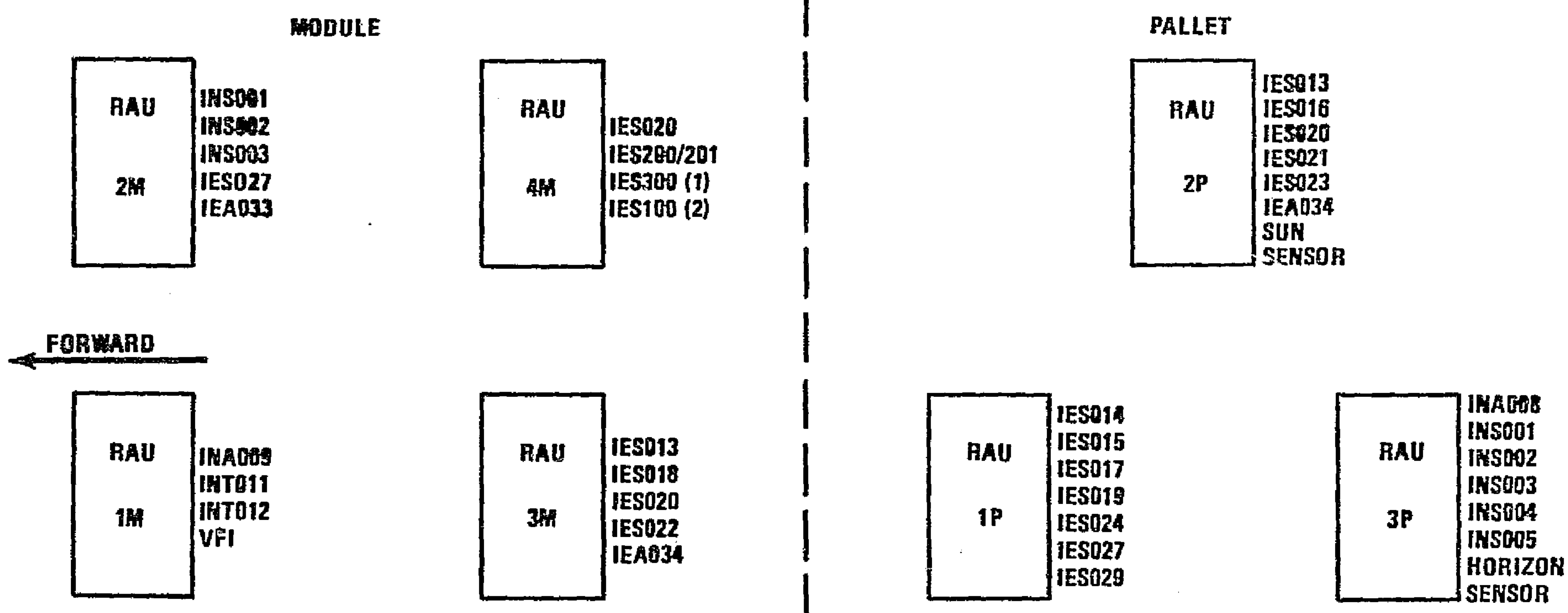
b. Reduce the number of PCM data channels for experiment 1ES019 by one. This solution is considered for the bus load analysis.

For more detail see Appendix C.

9.6.2 High Rate Multiplexer

Experiment outputs with data rates that exceed the capability of the RAU's interface directly to the HRM for multiplexing with other

REMOTE ACQUISITION UNIT (RAU) MARGIN SUMMARY



RAU	FLEXIBLE INPUTS	DISCRETE COMMAND	PCM DATA	PCM COMMAND	USER TIME CLOCK
1M	54	28	2	3	4
2M	87	45	0	0	1
3M	108	24	0	0	1
4M	100	61	1	0	1
TOTAL	349	158	3	3	7

RAU	FLEXIBLE INPUTS	DISCRETE COMMAND	PCM DATA	PCM COMMAND	USER TIME CLOCK
–	–	–	–	–	–
1P	75	36	-1	0	0
2P	21	6	0	1	2
3P	22	-7	2	2	4
TOTAL	118	35	1	3	6

(1) ~ 13 CONNECTIONS

(2) 1 CONNECTION

REMOTE ACQUISITION UNIT (RAU) MARGIN SUMMARY

TA' 9.2

ORIGINAL PAGE IS OF POOR QUALITY

high rate experiment outputs, GMLT, voice and other Spacelab data into a composite data stream, which is sent to the Ku Band Signal Processor (KUSP).

The HRM to the KUSP is the only path dedicated to the acquisition and transmission of digital data from Spacelab to Earth. As such, all experiments that require digital data for real time and post mission processing must link to the HRM either via the experiment computer or directly to a HRM channel input.

The format of the experiment digital input to the HRM must be organized to satisfy ground processing routines. The format will place restrictions in areas such as:

a. Sync Codes

b. Frame ID

c. Frame dimension

d. Experiment and mission ID codes

e. Time tags

f. Status and housekeeping data

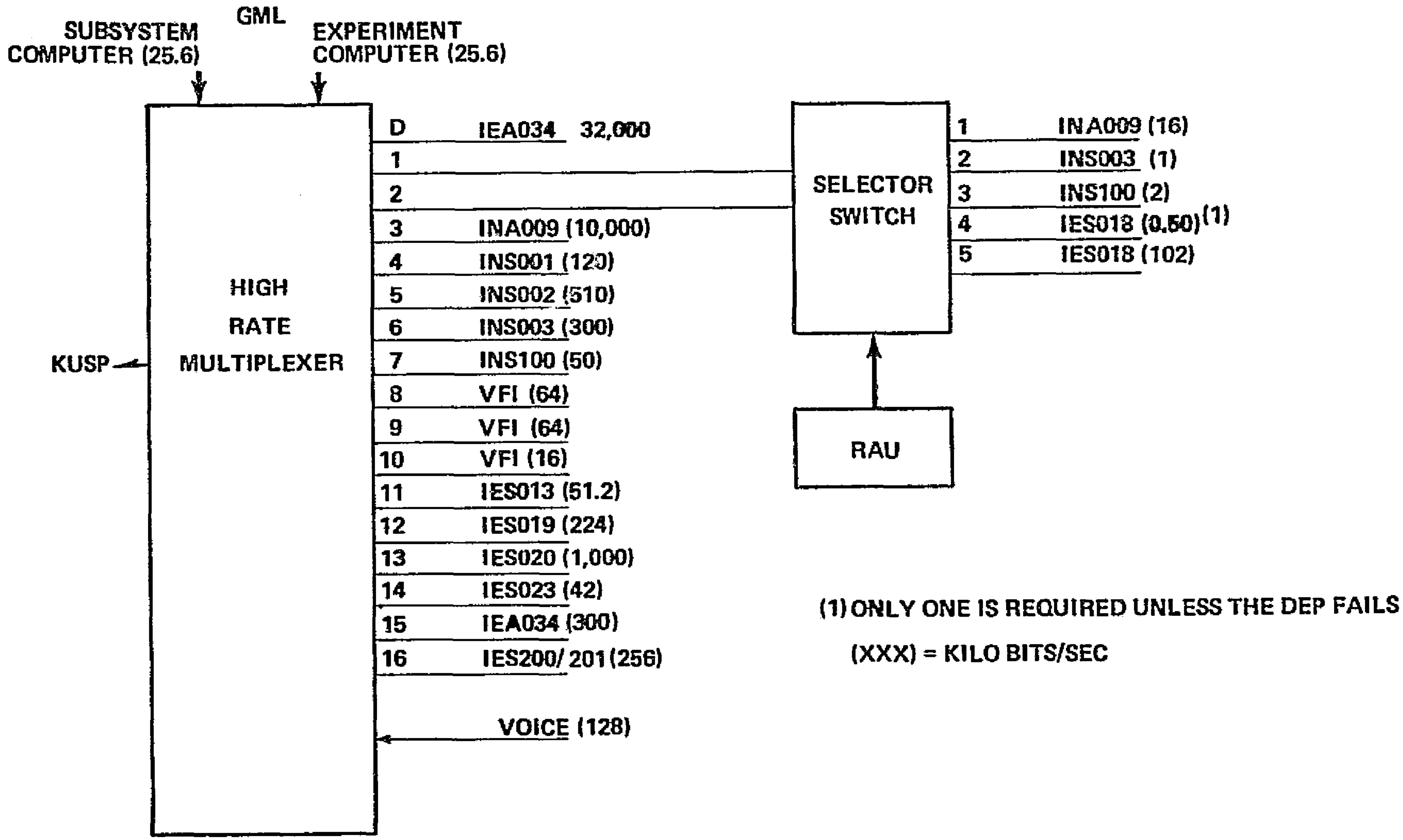
g. Science data

h. Word sizes

The total number of experiments that interface directly to the HRM exceeds the number of available inputs. Consequently, a premultiplex switch will be required as depicted in Figure 9.3.

Also shown are the experiment assignments to the respective HRM input channels and their corresponding maximum input rates in kilo bits per second.

Two HRM inputs were selected for the premultiplexer to allow for the possibility of two experiments interfacing to the premultiplexer switch to run simultaneously. Experiments were selected to interface the HRM by two criteria:



HRM CHANNEL ASSIGNMENTS
FIGURE 9.3

a. Low data rates

b. Minimum probability of running simultaneously

However, if the 1 KBPS output of 1NS003 and the 2 KBPS output of 1NS100 are interfaced to a RAU and the two outputs of 1ES018 are switched internal to the experiment (the 102 KBPS is only required if the 0.5 KBPS output fails) the requirement for a premultiplex can be eliminated.

In this case 1NA009 and 1ES018 will interface directly to the HRM.

During TDRSS outages the High Data Rate Recorder (HDRR) and Orbiter Payload Recorder will provide temporary data storage. The HDRR can record at rates of 1, 2, 4, 8, 16 and 32 MBPS and play back at selectable rates of 2, 4, 8, 16, and 32 MBPS. The Orbiter Payload Recorder can record up to 1 MBPS and play back at a corresponding rate. It is not intended that these recorders be used for permanent storage of data.

For detailed information on the HRM, see Appendix E.

9.6.2.1 Requirements Analysis

Table 9.3 is an assessment of the maximum requirement which could be placed on the HRM if timeline constraints, requirements for direct throughput, recorder playback, and video downlink requirements are ignored. This figure depicts the method of deriving an HRM mode configuration and means of determining the necessary HRM input parameters for control. Although a slight liberty was taken in assigning the HRM rate for experiment NA009, the maximum of a 16 megabit output will not be exceeded in actual timelined operation.

Since the HRM can accommodate only a fixed number of different input rates, it is necessary to select the closest possible rate to the experiment requirements consistent with HRM compatability. This is shown as the Nearest HRM Input Rate in column three of Table 9.3. Once selected, the combination of these rates cannot exceed the output rate selected.

When the highest possible requirement for the HRM programmable output is established, other considerations such as

Experiment Direct Inputs	Data Rate	Nearest HRM Input Rate
NA009	10 MB	10 MB
ES020	1 MB	1.167 MB
NS002	510 KB	667 KB
NS003	300 KB	333 KB
ES034	300 KB	333 KB
ES200/201	256 KB	333 KB
ES019	224 KB	333 KB
NS001	120 KB	166.7 KB
VFI	64 KB	83.3 KB
VFI	64 KB	83.3 KB
ES013	51.2 KB	62.5 KB
NS100	50 KB	62.5 KB
ES023	42 KB	62.5 KB
VFI	16 KB	20.83 KB
Sub total =	12,947.2 KB	13,707.63 KB

Switched Inputs
(any two)

NS003	1 KB	
NS100	* 2 KB	20.83
NA009	* 16 KB	20.83
ES018	0.5 KB (102 KB)	
Total	12,965.2 KB < 16 MB	13,749.29 KB

*Maximum

	13.75 MB
Voice	.1667
BIU 1	.0625
BIU 2	.0625
Overhead	1.6
HRM Output	15.6417 MB < 16 MB

HRM SETUP ASSESSMENT
TABLE 9.3

requirement for high bit rate, direct throughput must be assessed in conjunction with other experiment requirements. This is, in effect, the beginning of applying a timeline function to the operation of the HRM.

Table 9.4 shows the same basic grouping of the mission timeline into the fourteen segments utilized in the assessment of the Experiment Computer General Measurement Load Table (GMLT) requirements. The segments A thru N begin at the Ground Elapsed Time shown above the segment and relate to times of the Experiment Timeline utilized as baseline information. This broad cut was satisfactory for the GML assessment, but tends to indicate problems with the HRM and Ku Band Signal Processor in segments B, F, G, H and I.

Further breakdown of these segments (as shown for segment H in Table 9.5) shows that the problem of accommodation may still exist as evidenced by the circled areas in columns H1 and H7. However, the step description relating experiment operation reveals that scheduling conflicts are resolved. This is not surprising since the mission operation timeline does take into consideration equipment restrictions, at least to a minimal level in the scheduling of experiment operations.

Although total equipment accommodations appear to be sufficient from a timelined point of view, operational problems will exist due to the multiple changes of HRM formats required during the time interval around 79 hours and again around 89 hours of the current timelined operations. It is highly questionable whether or not the total receiving and transmission system can be reconfigured and verified rapidly enough to handle the timelined requirements. This problem needs a more detailed assessment and changes in the modeling system which generates the timeline in order to arrive at a mission profile which takes into consideration ground system operational constraints.

EXPERIMENT	RESTRICTING REQUIREMENTS	TIMELINE OPERATIONS														
		GET	0	12	32.5	52.3	54.5	56.6	62.5	73.5	91.0	97.4	117	122.5	136.8	148
		GML	A	B	C	D	E	F	G	H	I	J	K	L	M	N
NA009								10MB	10MB	10MB	10MB					
ES020			1MB	1MB	1MB				1MB	1MB						
NS002	VIDEO			510	510				510	510	510	510	510			
NS003	VIDEO									300	300	300	300	300	300	
EA034	32MB(D)									300	300	300	300	300		
ES200/201	VIDEO			256											256	
ES019				224	224	224	224			224	224					
NS001				120	120	120	120	120	120	120	120	120	120	120	120	
VFI			64	64	64	64	64	64	64	64	64	64	64	64	64	64
VFI			64	64	64	64	64	64	64	64	64	64	64	64	64	64
ES013				51.2					51.2	51.2	51.2					
NS100	VIDEO			50	50	/	50		50	50	50	50	50	50	50	
ES023				42	42	42	42	42	42	42	42					
VFI			16	16	16	16	16	16	16	16	16	16	16	16	16	16
NS003										1	1	1	1	1	1	
NS100				2	2											
NA009								16	16	16	16					
ES018				0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5					
TOTAL(KBS)			1,144	2,401	2,093	531	581	10,323	11,934	12,759	11,759	1,425	1,425	915	871	144

(D) EA034 REQUIRES 32MB BYPASS MODE OF HRM

NOTE: ALL VALUES KILO BITS UNLESS OTHERWISE STATED

HRM OUTPUT REQUIREMENTS

TABLE 9.4

EXPERIMENT	RESTRICTING REQUIREMENT	TIMELINE OPERATIONS								
		GET	73.5 91.0	73.5	74.2	75.6	77.0	79.4	85	87.8
		GML	H	H1	H2	H3	H4	H5	H6	H7
NA009			10MB	X				X		X
ES020			1 MB					X	X	X
NS002	VIDEO		510	X				X	X	X
NS003	VIDEO		300				X	X	X	X
EA034	32MB(D)		300							
ES200/201	VIDEO		—							
ES019			224						X	
NS001			120	X		X	X	X		
VFI			64	X	X	X	X	X	X	X
VFI			64	X	X	X	X	X	X	X
ES013			51.2	X				X		X
NS100/101,102	VIDEO		50		X	X				
ES023			42	X	X		X	X		
VFI			16	X	X	X	X	X	X	X
NS003			1				X	X	X	X
NS100			2		X	X				
NA009			16	X				X		X
ES018			0.5						X	
	TOTAL		12,760	10,883	238	316	607	12,184	2,182	12,024

NOTE: ALL RATES IN KBS EXCEPT WHERE NOTED

DETAIL OF TIME SEGMENT H

TABLE 9.5

9.6.3 Analog/Video

Analog/video requirements from five experiments were evaluated. The experiments are 1NS002, 1NS003, 1NS101, 1NS102 and 1 ES200/201, and the proposed method of accommodating them within the constraints of the CDMS is shown in Figure 9.4. Five television cameras will provide video data from the experiments and one of the experiments (1NS002) will generate a wideband analog signal for downlink transmission. These signals will be routed, as required, by means of a video switch to a TV monitor, to the orbiter CCTV system and to and from an analog/video recorder. The video switch will be operable by computer software, by the payload specialist (either manually or by use of the Spacelab keyboard) or by ground command. It will interface with the video switching network in the orbiter, which will provide additional routing capability.

The video monitor, provided by Spacelab, will permit viewing of any of the five TV cameras. Downlink transmission or onboard recording can be accomplished simultaneously with monitor operation.

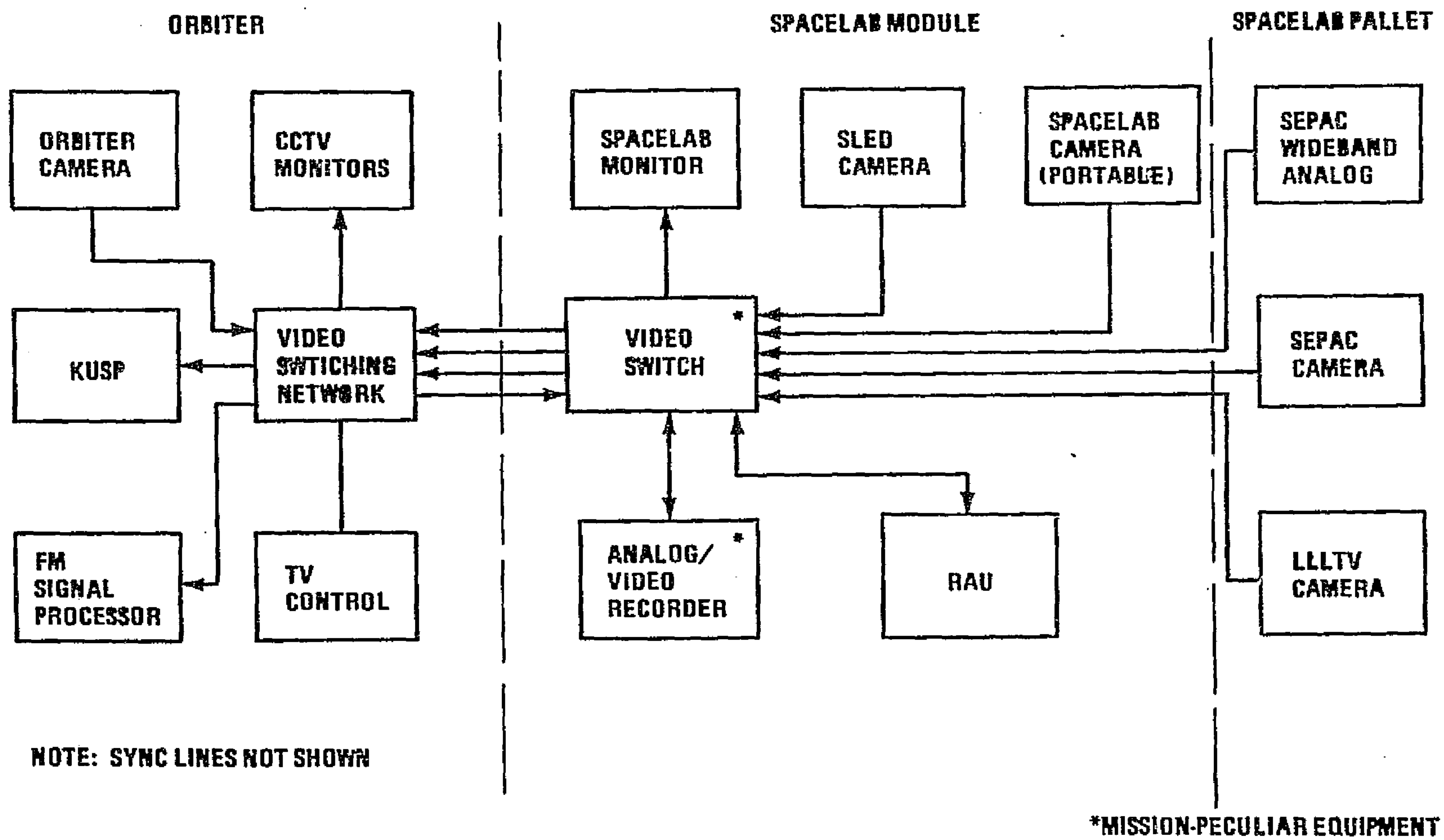
The analog/video recorder is capable of recording either one or two channels of video or other wideband signals.

The output signals from the SEPAC (1NS002) monitor camera, the Low-light-level TV camera (1NS003) and the SEPAC plasma-wave measuring equipment will be accommodated either individually or simultaneously (according to the timeline) as follows:

a. The SEPAC monitor camera output will be routed to the Spacelab monitor only.

b. The Output of the LLLTV camera, when operated alone, will be viewed on the monitor, transmitted to ground or both simultaneously.

c. The plasma-wave measurement, when performed simultaneously with the LLTV imaging, will be recorded while the LLTV signal is transmitted to ground. In the absence of TDRS contact, both signals will be recorded for later transmission to ground.



ANALOG/VIDEO SYSTEM FOR SPACELAB MISSION NO. 1

FIGURE 9.4

d. The Sled Experiment (1ES200/201) presently requires one channel of video, an infrared camera to monitor the eye movement of the Payload Specialist during the course of conducting the experiment. However, under consideration is the possibility of monitoring the motion/posture of the specimen, either simultaneously or on a time shared basis. Two approaches appear to be feasible at this time: (1) employ a split screen technique, (2) transmit one channel in real time and record one channel for delayed transmission.

Experiments 1NS101, 1NS102 (except for part of FO4) and 1ES200/201 will have their requirements satisfied by a portable camera provided by Spacelab. This camera will be mounted in a suitable location to provide a view of the sled operation for 1NS102 and may be hand held for observing the preparation of plans for experiment 1NS101. The time lapse images to be obtained in that experiment will be stored by a video recorder which is part of the experiment package. The video camera and recorder that will be used for obtaining the time-lapse images will not interface with the Spacelab video system.

That portion of experiment F04 of 1NS102 which requires observation of a waking crew member after a normal sleep cycle will be accommodated by use of an orbiter camera which will be located at the crew sleep station in the orbiter mid-deck. That portion of the experiment which involves observation of the crew member in the module will use the portable camera which was previously mentioned for use with 1NS101 and the other experimental activities of 1NS102.

The method to be used for synchronizing the cameras with the Spacelab Monitor, and perhaps with the Orbiter monitors, is yet to be determined. Use of the Orbiter-provided synchronization pulse, use of the camera provided pulses and generation of a synchronization pulse within the Spacelab switching system are methods presently under consideration. Development of a satisfactory method of synchronization is a subject of further study, and does not appear to pose any insurmountable difficulties.

9.6.4 Experiment Computer Data Bus

After the experiments were assigned to RAU's according to the constraints/groundrules in section 9.5.2.1 and Appendix D, an analysis of the load on the experiment computer data bus to collect experiment data and to issue commands was made. To do so the following assumptions were made:

a. Data are collected from the RAU's and sent to the HRM with separate command triplet sets. Note: A command triplet is composed of three 16 bit words, and a set of triplets executed over 1 second period constitutes one GML. Word one defines the Experiment Computer memory address that data will be read from or written to when executing the triplets. Word two defines the skipping indicator, op code of the command and word count relative to the command. Word three provides the RAU address and more detail relative to RAU commands.

b. GML data for HRM only will reside in a separate buffer from the PCMMU data.

c. Continuous operation of an experiment over a given time segment,

Each triplet can access, and store up to 64-16 bit words, and each triplet has an attendant overhead during which no data can be transferred on the bus. The overhead for data acquisition is:

(1) Discrete and Serial input data = 115 microseconds

(2) Analog input data = 125 microseconds

(3) And for data to the HRM = 175 microseconds

Consequently, efficient utilization of the data bus was dictated. With this in mind, the constraints/groundrules listed in section 9.5.2.1 were followed.

Data from the requirements as summarized in Appendix A and the experiment groupings as defined in 9.4 were next analyzed to project the load on the experiment computer summarized in Table 9.6. Only the busiest 10 millisecond time segment out of a given second was considered.

Time computations were made according to the following:

a. HRM output = (175 + 20 N) μ sec

b. Analog Input = (125 + 20N) μ sec

c. Discrete & Serial Input = μ sec

Software overhead to support GML requires 2.59 milliseconds of the 10 millisecond minor cycle time slot. (1.47 ms for set up and 1.12 ms for wrap up software).

The time for a worst case asynchronous data bus I/O operation will be reserved for each minor cycle and the maximum time required to perform the worst case operation is 1.685 milli-seconds. The worst case being a three word serial output followed by two 32 word serial inputs (see Appendix D). This operation is required when interfacing an RAU to three serial inputs and two outputs to the Spacelab Payload Standard Modular Electronics (SPSME). Total time = [115 + (20x3)] = 1.685 ms.

Thus, the maximum GML time is limited to: 10 ms - 2.59 ms - 1.685 ms = 5.725 ms.

The data presented in table 9.6 were based on the above time computations. Shown are the bus times for each time segment which include the time that the data are actually on the bus, associated overhead and the margins in both microseconds and % of available time. These margins represent growth potential and are based on the most available conservative data. Also, while not optimum, data routed to the computer were immediately routed to the HRM with separate triplets. Further studies are planned to determine the optimized procedures for assignment of RAU measurements and generation of the resulting triplets.

Based on the data presented in this section, one GMLT for the total payload is feasible with the utilization of skip triplets when an experiment is inactive, and should be a design goal for Spacelab 1 payload integration. This will greatly facilitate realtime and post mission data processing. Also, an Experiment Computer I/O-HRM data rate of 25.6 KBPS will accommodate the CDMS requirements as presently defined and understood. Data routed from the Experiment Computer I/O to the HRM will be formatted into a PCM format that will be compatible with standard telemetry processing equipment at the POCC and GSFC. The experiment computer will insert the appropriate synchronization, time, identification, and error words, along with the data gathered by the RAU's into the format. Also, sufficient words will be allocated to allow for the insertion of certain Experiment Computer and Orbiter related data. Examples are: state vector, orbiter attitude, command tables, and selected processed information.

TABLE 9.6 DATA TRAFFIC SUMMARY

TIME SEGMENT		A	B	C	D	E	F	G
TIME FOR DATA ON BUS (μs)		1640	2485	2765	1985	2315	2380	2090
OVERHEAD (μ s)		4685	4685	4685	4685	4685	4685	4685
MARGINS	(μ s)	3675	2830	2550	3330	3000	2935	3225
	%	64.2	49.4	44.5	58.2	52.4	51.2	56.3

TIME SEGMENT		H	I	J	K	L	M	N
TIME FOR DATA ON BUS (μ s)		2260	2785	1460	1880	1890	2200	1890
OVERHEAD (μ s)		4685	4685	4685	4685	4685	4685	4685
MARGINS	(μ s)	3055	2530	3855	3435	3425	3115	3425
	%	53.4	44.2	67.3	60.0	59.8	54.4	59.8

OVERHEAD INCLUDES:

1) MAXIMUM TIME REQUIRED FOR HRM OVERHEAD = 410 MICRO SECONDS
2) TIME REQUIRED FOR WORST CASE ASYNCHRONOUS I/O OPERATIONS = 1,685 MICRO SECONDS
3) EXPERIMENT COMPUTER SOFTWARE =2590 MICRO SECONDS

ORIGINAL PAGE IS OF POOR QUALITY

The analysis of the data bus traffic supports the utilization of a data stream up to a 25.6 KBPS capacity. This rate will support all requirements for data rates up 1, 10, 100 samples per second and provide a sufficient margin for growth and non GMLT data. Also, there is enough capacity for a fixed format for the mission duration; however, a decision regarding this should be deferred until the total contents of the stream are defined and the full capability of ECOS is understood.

There are several possible formats that can be considered, see Appendixes C and D. The smallest one that can support Spacelab 1 is 10 minor frames of 64 words each with a data rate of 10.24 KBPS. This one, however, precludes 100 s/s data and does not provide enough growth margin to accommodate non GML data.

The data format presently considered for Spacelab 1 is illustrated in Figure 9.5. This format has the following characteristics:

a. Rate of 25.6 KBPS

b. Major Frame comprised of 20 minor frames x 80 channels.

c. Channels 1 and 2 are designated for sync (24 bits for sync, 8 bits for minor frame identification).

d. 100 samples/sec measurements will occupy every 16th channel as required, for example: 20, 36, 52, 68 of each frame in the format.

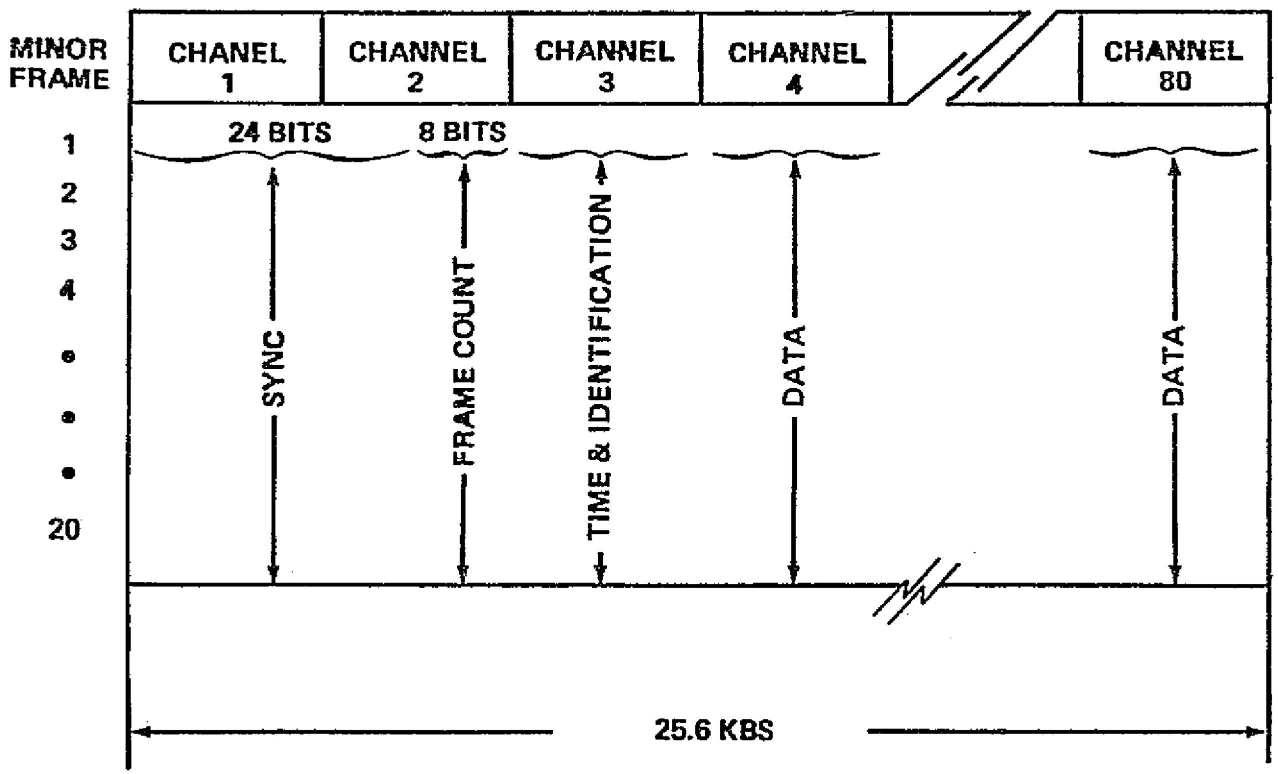
e. The following data will be located in channel 3:

(1) Source ID - an eight bit byte that identifies the format as a GML format.

(2) GML format - an eight bit byte to identify the location of all measurements within a specific GMLT.

(3) GMT - Time for the first minor frame days, hours, minutes, seconds and 10 millisecond intervals.

(4) Error ID - indicates the type of error that generates an error interrupt to the Experiment Computer



GMLT - HRM FORMAT

FIGURE 9.5

(5) Mission ID - identifies the mission

(6) Subframe number - 10 ms GML count

(7) Index Word - indicates which set of memory locations (toggled every 250 ms) containing GMT was last updated.

(8) All other allocations will contain data

9.6.5 Data Flow

The data flow analysis summarized in this section addresses the compatibility of the onboard tape recorders to adequately accommodate the digital and analog data during TDRS blackout periods and to perform the required tape recorder playbacks during the available TDRS coverage. Compatibility with TDRS and the other network elements was also considered.

The data flow simulation was accomplished by integrating the experiment operating timeline, the associated experiment data rates, and the TDRS coverage. The result of the simulation were then evaluated against the guidelines to minimize data losses and partial tape recorder dumps.

TDRS Coverage

The TDRS coverage based on the August 1977 timeline is as follows:

Percent Coverage = 63%

Maximum Gap = 113 Minutes

Maximum Contact = 84 Minutes

Average Gap = 20 Minutes

Average Contact = 34 Minutes

This coverage assumed that the TDRS satellites are located at 41 W and 171 W, and the Orbiter Antenna kit (COMMB) is not used.

9.6.5.1 Digital

The digital data flow analysis addresses the High Rate Multiplexer (HRM) wideband data and assumes the utilization of the Spacelab High Data Rate Recorder (HDRR). The Payload Recorder is not considered in this study due to its limited capability. The maximum record rate of the Payload Recorder is only 1 MBPS, and past studies have shown that its low record to dump ration is incompatible with the data requirements. Additionally, data gaps introduced by the Payload Recorder following each track change make it undesirable for science. However, it should be pointed out that the Payload Recorder may be required during periods of high analog and video data flow, since its low rate playback (1 MBPS) can be accomplished in Mode 2 of the Ku-band. Playback of the HDRR requires Mode 1 which will inhibit analog or video downlink.

The minimum record rate of the Spacelab HDRR is a 1 MBPS which implies that the minimum composite data rate out of the HRM is at least 1 MBPS. To constrain the HRM formats to a minimum of 1 MBPS is consistent with the guideline to minimize the number of HRM formats.

Most of the experiment data rates are in the low to medium range (less than 1 MBPS). Experiments which equal or exceed 1 MBPS are:

a. ES020 - 1MBPS

b. NS009 - 10MBPS

c. ES034 - 32 MBPS

The high rate experiments operate for relatively short periods of time and do not impact the data flow timeline. Other inputs to the HRM which were considered are:

a. VFI - 64KBPS, 64 KBPS, 16 KBPS (3 channels)

b. Experiment computer I/O channel - 25.6 KBPS

c. Subsystems computer I/O channel - 25.6 KBPS

d. Voice - 128 KBPS

Shown on Figures 9.5.1-10 are the downlink data rate profile, the real time data rate profile, Spacelab HDRR percent full, and the TDRS communications timeline. The downlink data profile represents the sum of the real time data plus the HDRR playback data (when present) during TDRS coverage. During TDRS blackout periods the downlinked data rate is zero and the data represented by the real time data profile must be recorded. The recorder utilization is shown in the bottom plot entitled Spacelab HDRR Percent Full. Following the TDRS blackout, the tape recorder is played back at the fastest rates possible. For most of the mission, the real time data rate is 1 MBPS, so that when recorded, the maximum playback will be 16 MBPS. Therefore, the typical downlink data rate during tape recorder playback is 17 MBPS (1 MBPS real time and 16 MBPS - dump).

The maximum downlinked data rate over the mission is 33 MBPS. This occurs for short duration (.06 hours) during the operation of the Microwave Scatterometer, ES034. The 32 MBPS generated by ES034 will flow through the direct channel thus bypassing the HRM, and be downlinked over channel 3 (2-50 MBPS), mode 1 of Ku-bank system. Data from all other sources will be multiplexed by the HRM, and the 1 MBPS data stream will be downlinked over Channel 2 (16 KBPS - 2 MBPS) of the Ku-band system. During TDRS blackout periods the 32 MBPS data stream will be routed to the HDRR and the 1 MBPS data stream will be routed to the Payload Recorder.

It should be noted that presently the maximum downlink the network can support is approximately 44 MBPS due to a DOMSAT limitation. This implies that the maximum HRM format is constrained to 32 MBPS. Also the playback of the HDRR at its maximum rate of 32 MBPS must be routed to the HRM bypass channel, which will require Payload Specialist involvement or be multiplexed at a reduced rate, up to 16 MBPS.

Considering these requirements, guidelines and constraints, the analysis of the digital data flow revealed no significant problems. The minimum reserve of the HDRR never goes below 40%, no partial tape recorder dumps are required, and no data are lost.

9.6.5.2 Analog/Video

The SL-1 requirements for analog and video data flow as defined by the August 1977 timeline will probably exceed the capability of the onboard recorder and available TDRS communications to prevent data losses. Additional excessive partial dumps will be required which will add significant complexity to the operation of the recorder. The

SPACELAB 1 - DIGITAL DATA FLOW

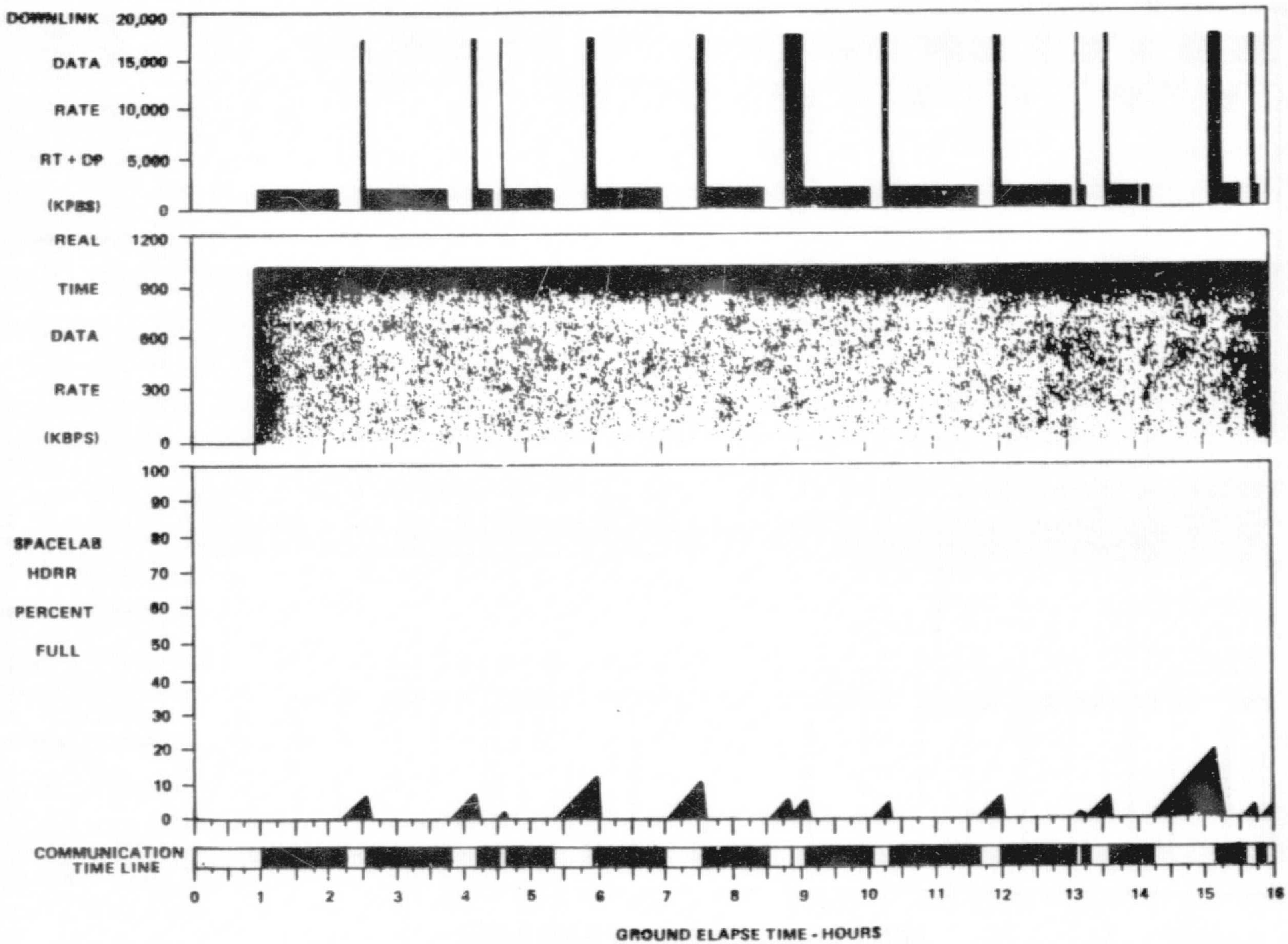


Figure 9.5.1

SPACELAB 1 - DIGITAL DATA FLOW

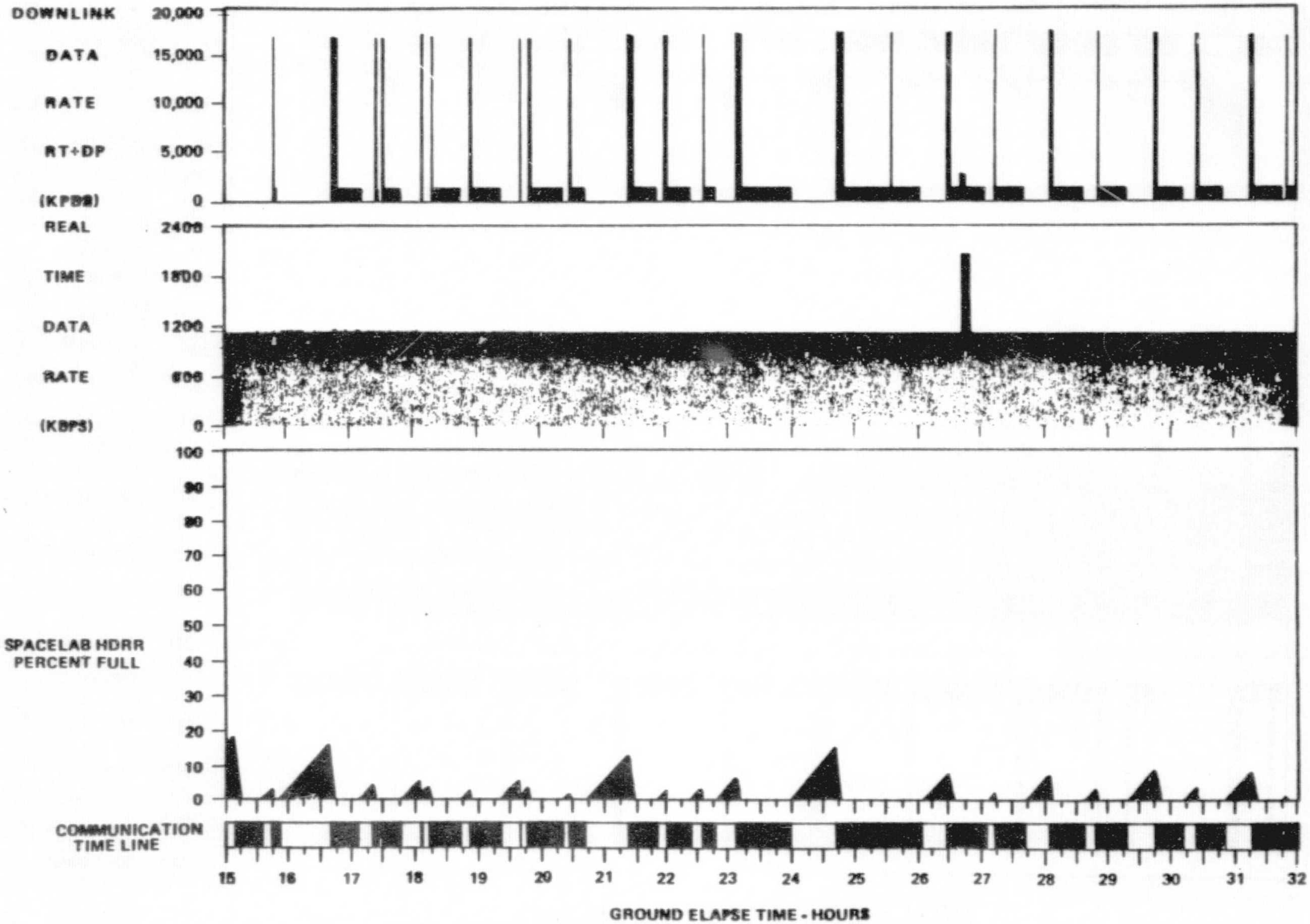


Figure 9.5.2

SPACELAB 1 - DIGITAL DATA FLOW

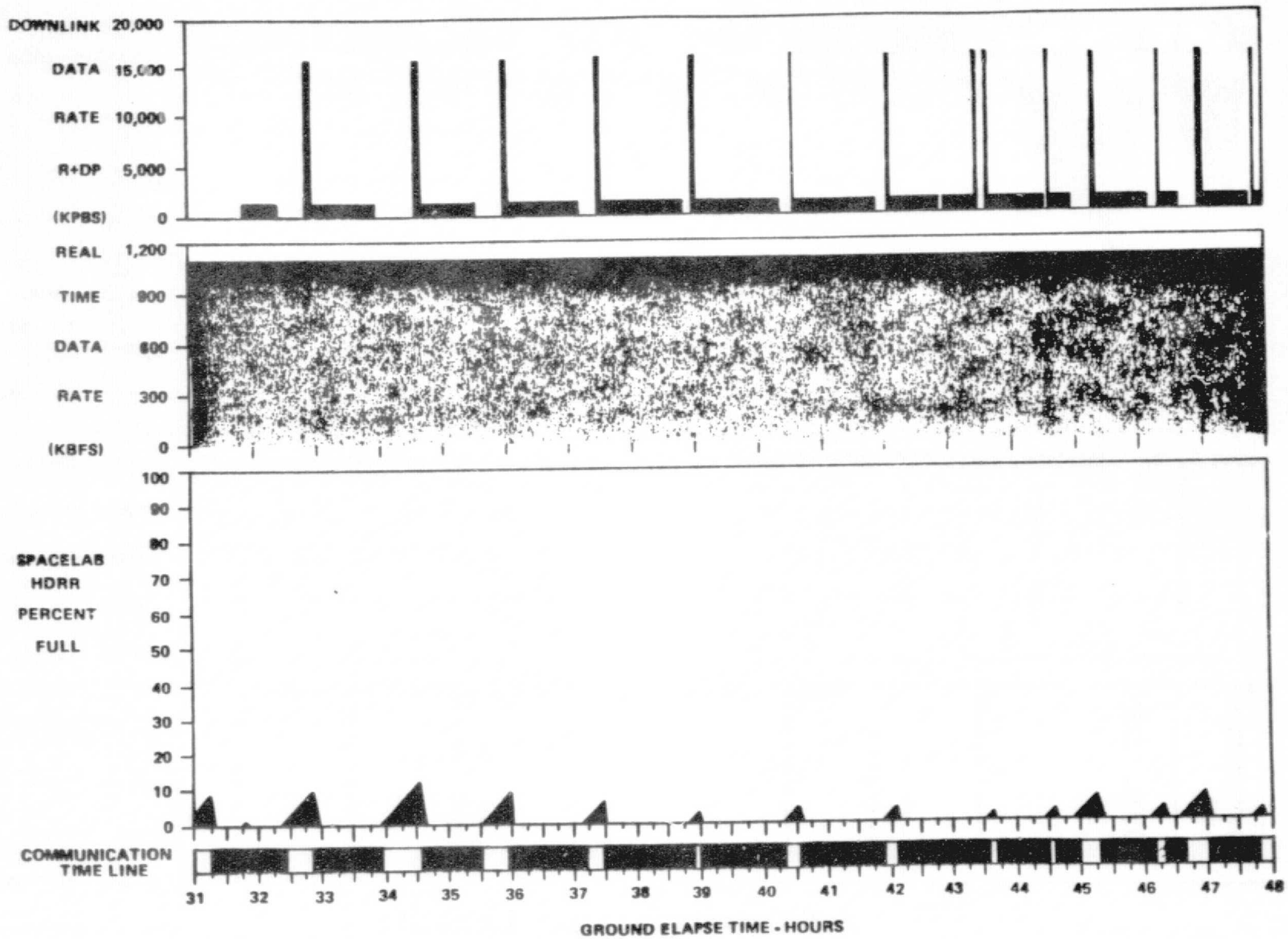


Figure 9.5.3

SPACELAB 1 - DIGITAL DATA FLOW

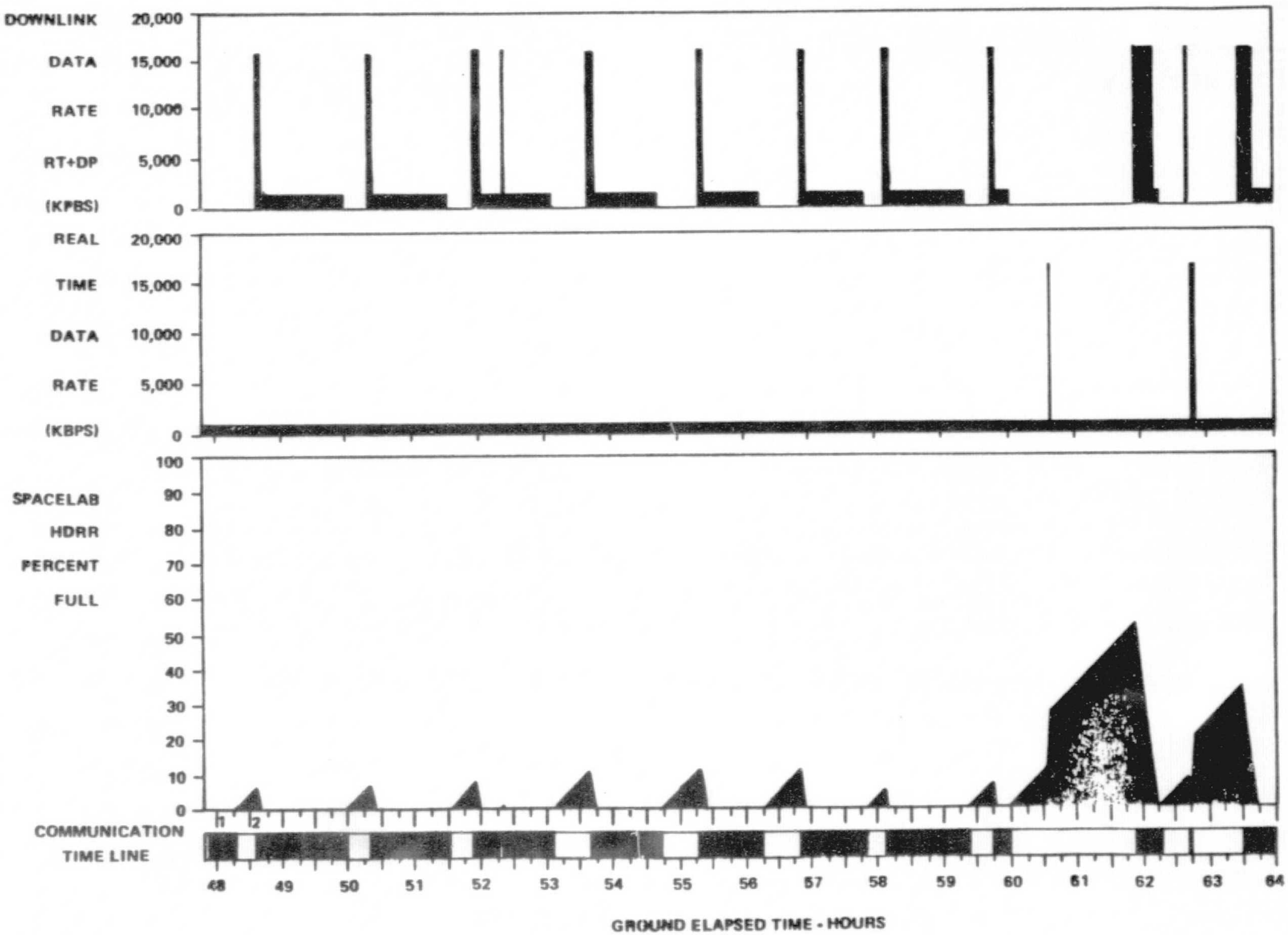


Figure 9.5.4

SPACELAB 1 - DIGITAL DATA FLOW

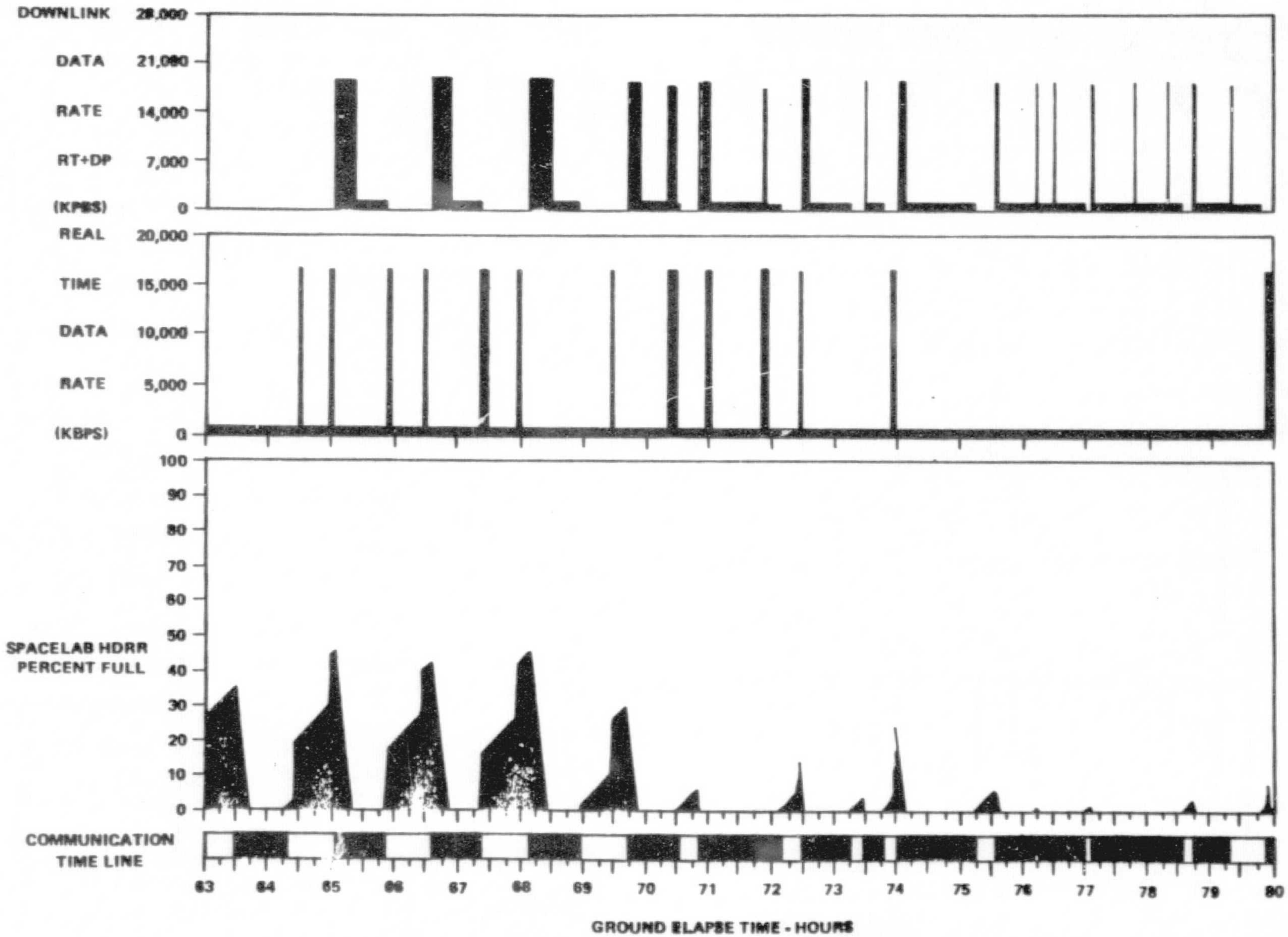


Figure 9.5.5

SPACELAB 1 - DIGITAL DATA FLOW

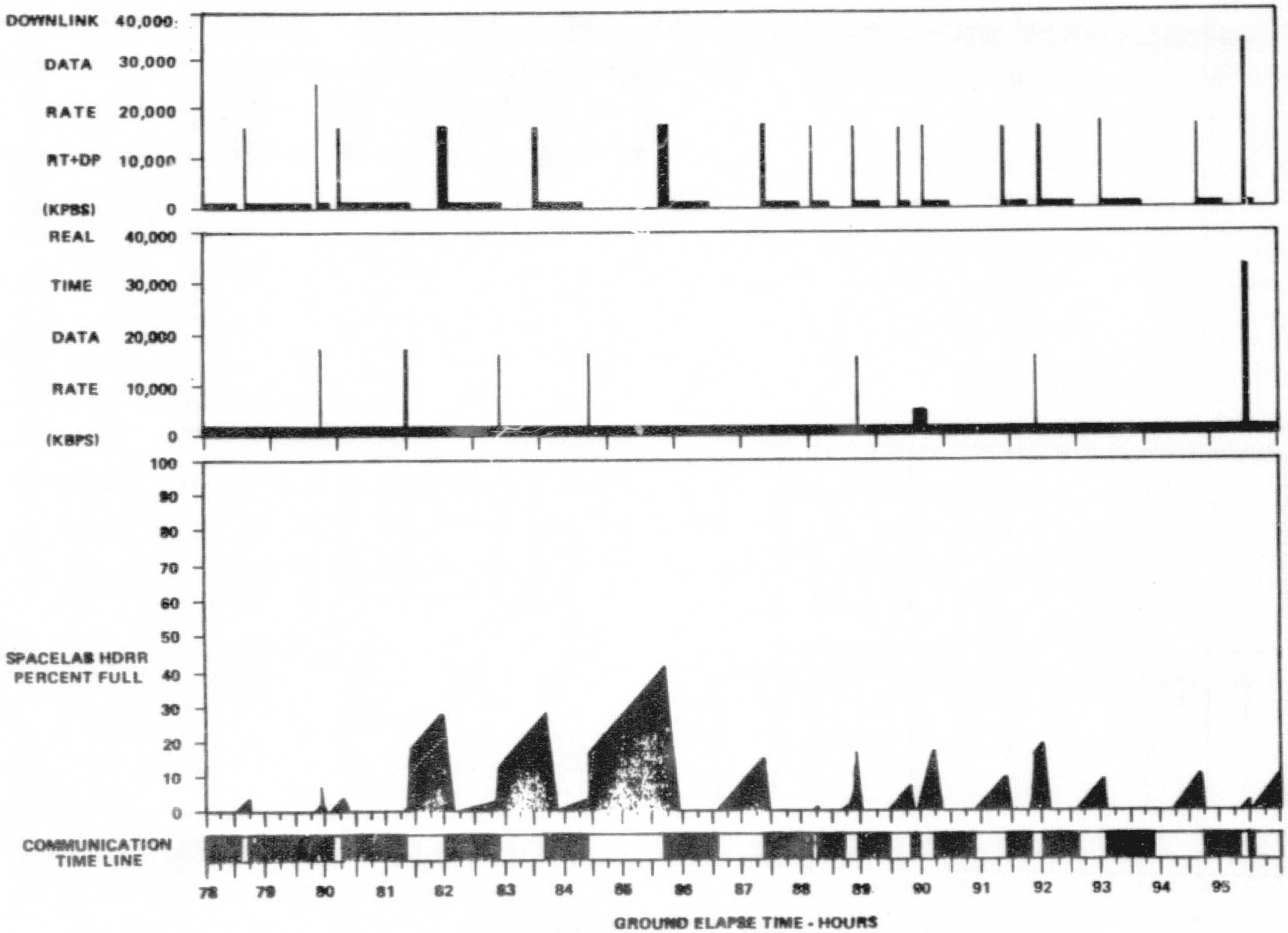


Figure 9.5.6

SPACELAB 1 - DIGITAL DATA FLOW

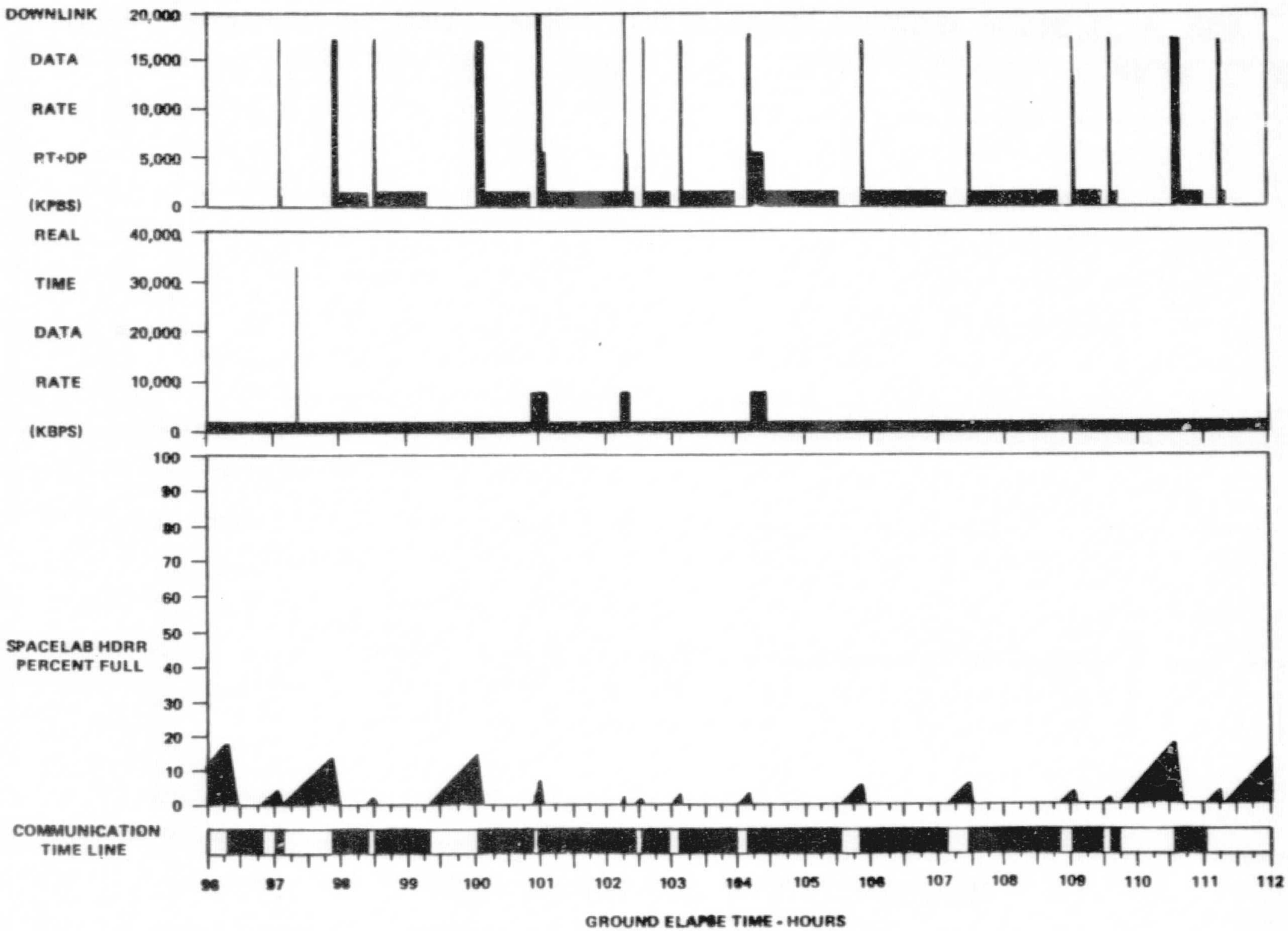


Figure 9.5.7

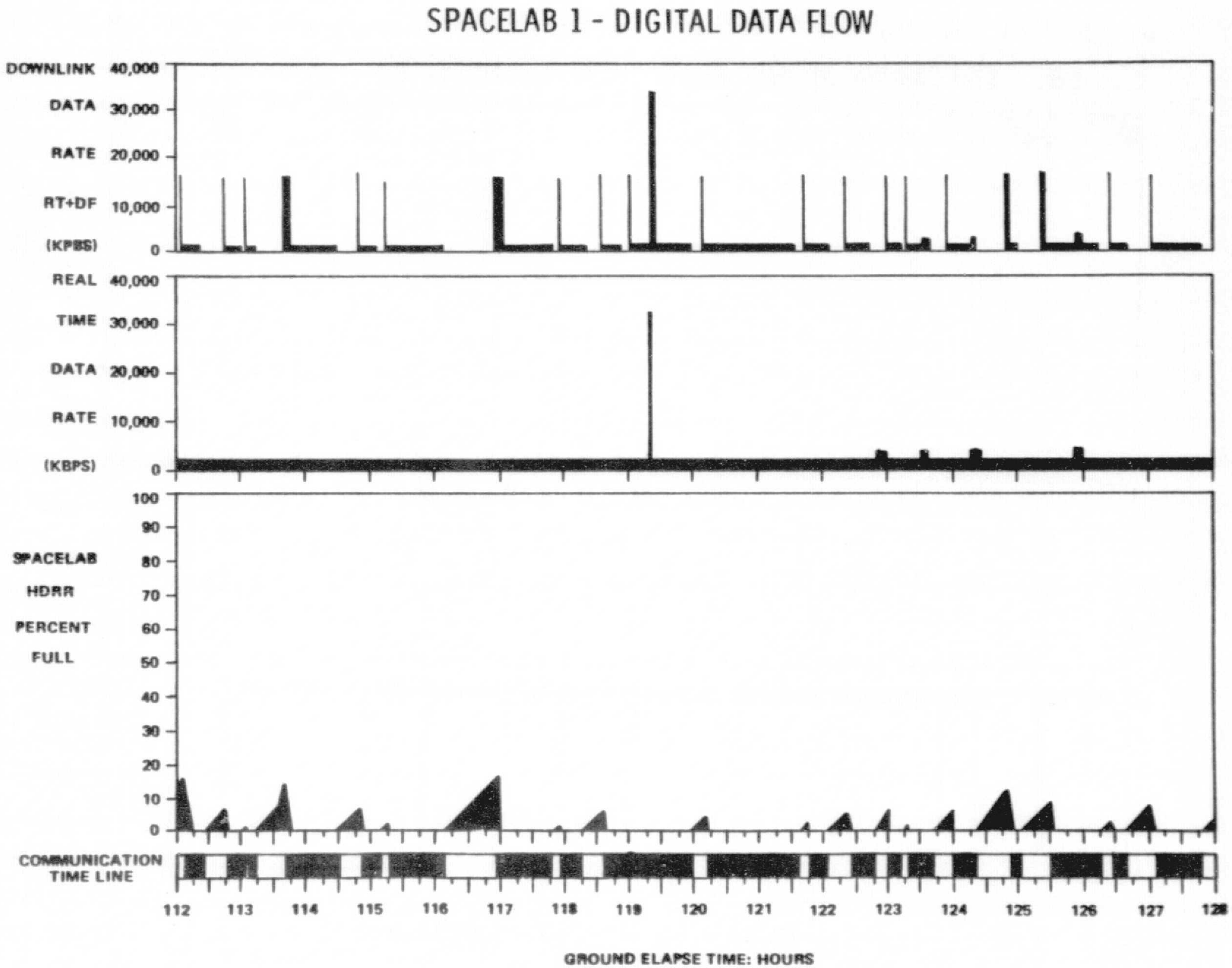

SPACELAB 1 - DIGITAL DATA FLOW
DOWNLINK DATA RATE RT+DF (KPBS)
40,000
30,000
20,000
10,000
0
REAL TIME DATA RATE (KBPS)
40,000
30,000
20,000
10,000
0
SPACELAB HDRR PERCENT FULL
100
90
80
70
60
50
40
30
20
10
0
COMMUNICATION TIME LINE
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
GROUND ELAPSE TIME: HOURS

Figure 9.5.8

SPACELAB 1 - DIGITAL DATA FLOW

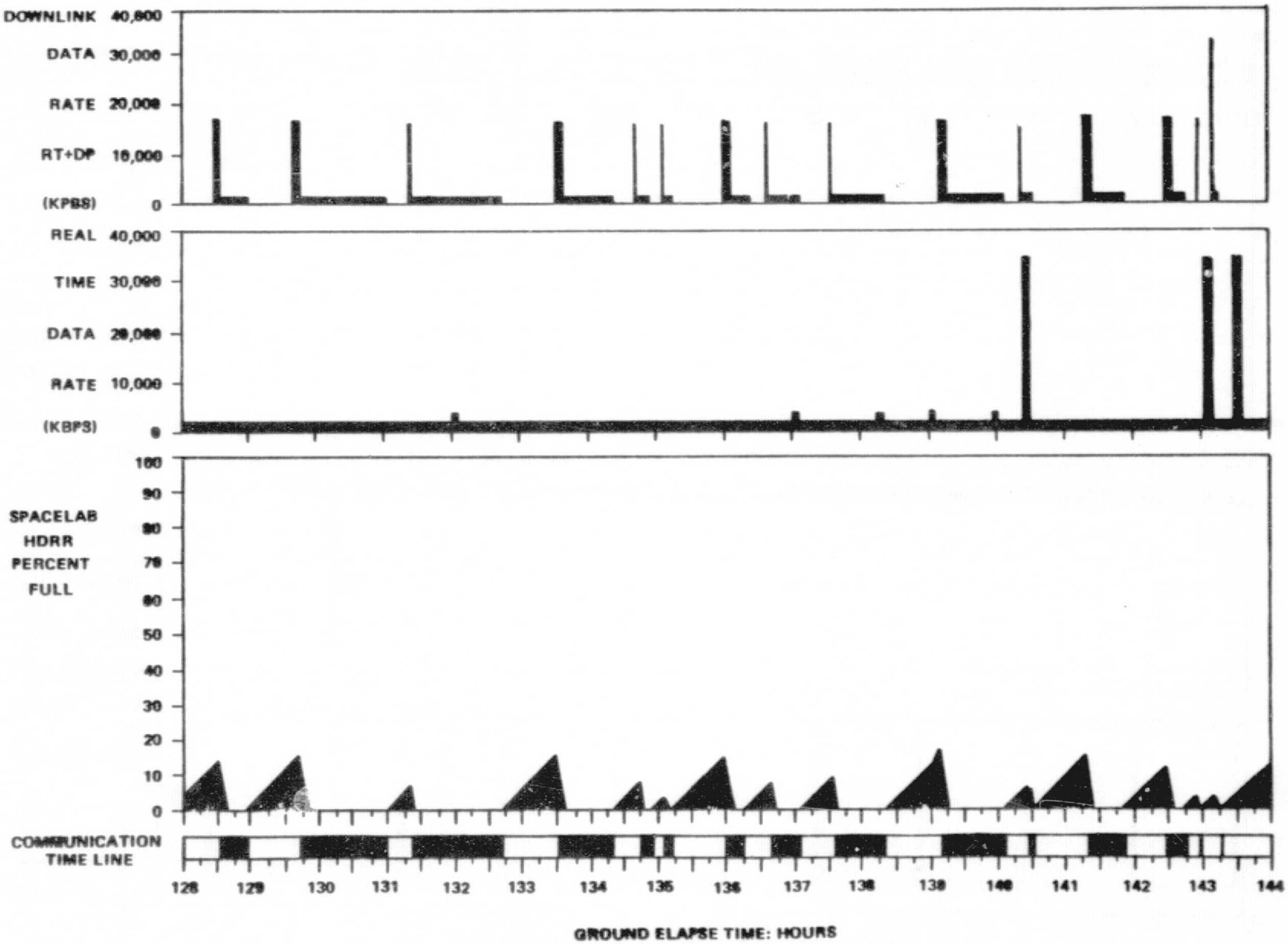


Figure 9.5.9

SPACELAB 1 - DIGITAL DATA FLOW

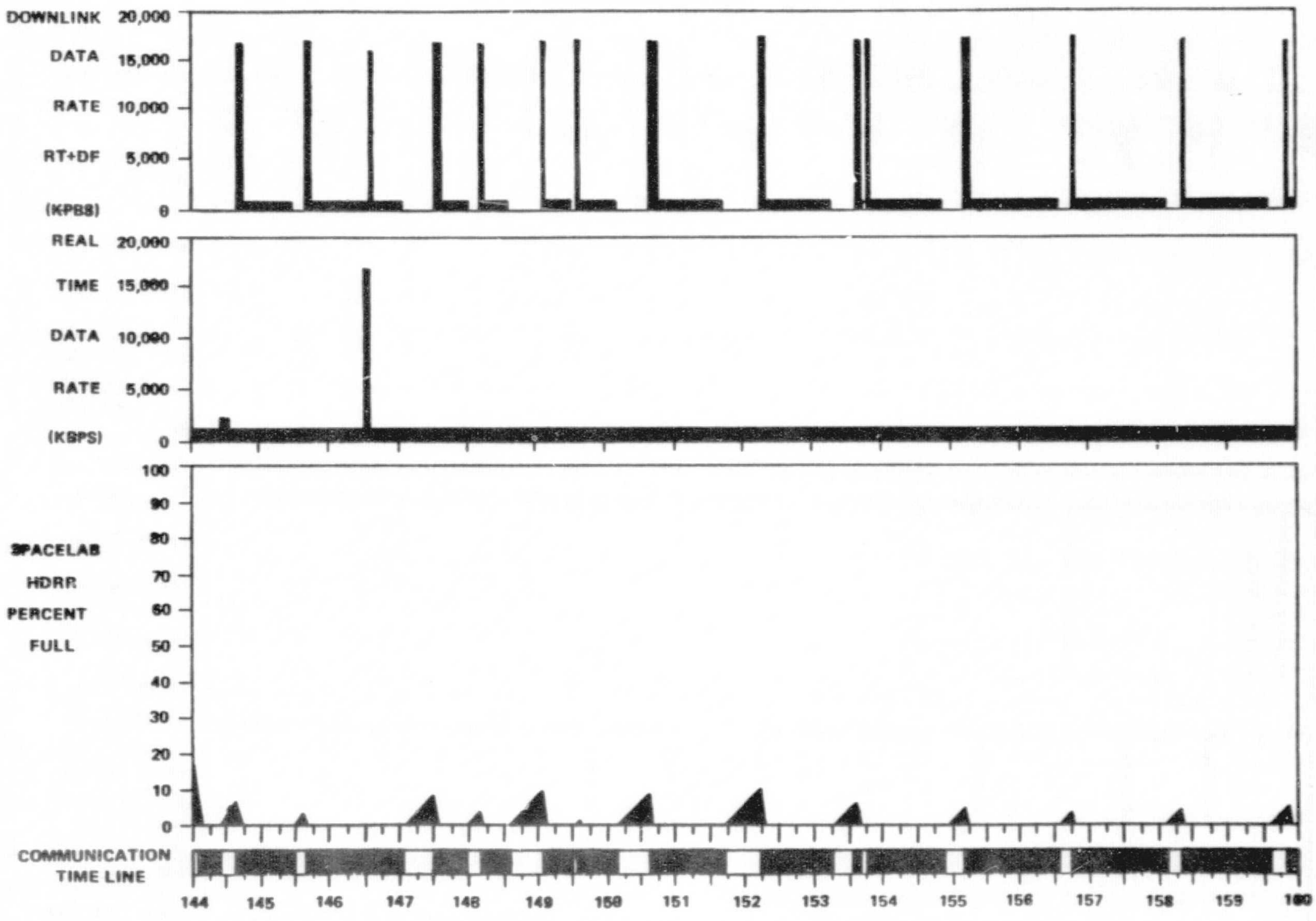


Figure 9.5.10

factors which affect the analog data flow are:

a. The 4.5 MHz downlink will accommodate only one analog or video signal at a time.

b. Video/Analog data can be downlinked only in Ku band mode 2. If the digital rate exceeds 2 MBPS, video/analog data must be recorded.

c. The playback rate of the video/analog recorder is 1:1.

d. The recorder playback must be in the forward mode, which requires a rewind of up to 6 minutes following a record cycle.

e. Two channels of data can be recorded simultaneously; however, both channels must be downlinked serially before that portion of the tape can be reused.

f. The recorder can record one source for up to one hour, and two sources for one-half an hour.

A typical period of high analog and video data flow (72-91 hours) is shown in Figure 9.6. The analog and video requirements at the top of Figure 9.6 reflect a combined total of 20 operations of 1NS002, 1NS003, and 1NS102. These requirements, particularly 1NS002 which has both analog and video, place a tremendous burden on the data system. The plots on the lower half of Figure 9.6 reflect the utilization of analog/video recorder in terms of percent full. As the data is recorded the percent full will increase, and as it is dumped, percent full will decrease. During this period a total of 23 recorder dumps were performed on channels 1 and 2. Of that total 14 dumps were only partially completed, that is, the dump had to be terminated due to the loss of TDRS coverage or because an experiment requiring analog or video data had been activated.

It should be noted that the recorder operation depicts on optimal utilization which is unlikely under mission conditions. With the magnitude of partial dumps and the complexity required to manage the recorder, it is most probable that considerable data would be lost.

Two recommendations can be made to alleviate this problem. First, the operation of these experiments must be separated

EF803

ANALOG/VIDEO DATA FLOW

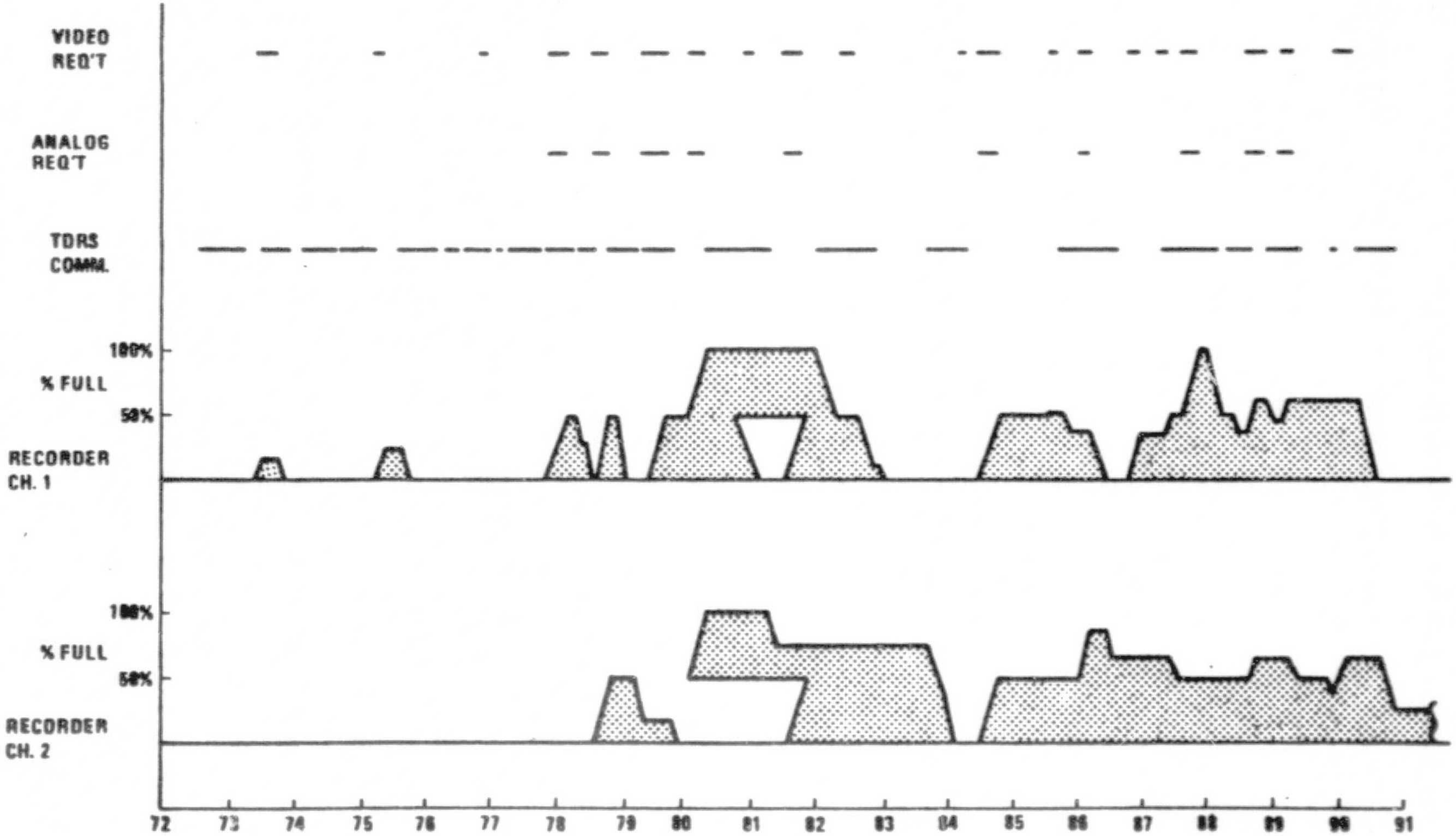


Figure 9.6

by sufficient time to permit a complete recorder playback. If one signal is recorded, a time equal to the record time must be scheduled during TDRS coverage, prior to the next recording requirement. If two signals are recorded, that time must be reduced to allow a serial playback of both channels.

Secondly, experiments requiring analog or video data should be scheduled during TDRS coverage as much as possible. This would be particularly helpful during the operation of NS002.

9.8 CONCLUSIONS:

a. The total payload data requirements are within the CDMS hardware capabilities - no major incompatibilities were identified. However, this conclusion is reached independent of the software study. A final CDMS position is not possible without considering the CDMS hardware and software as a single resource.

b. There is sufficient margin for growth on the data bus.

c. There is potential difficulty in accommodating all analog/video requirements.

d. Data rates will not exceed the projected TDRS bandwidths.

NOTE: There is no sun sensor on Spacelab Mission 1. Although a sun sensor was assumed in the analysis of the Command and Data Management System, the results and conclusions are not changed.

9.9 DATA CHARTS

Data charts 1A thru 2C provide an assessment of the Command and Data Management System (CDMS) requirements necessary to satisfy the expressed and in some instances implied requirements of the experiment complement for Spacelab I. Where portions of an experiment were located both in the module and on the pallet with no indications of split relative to the command or data requirements, an estimate of the split was made in order to arrive at a somewhat more realistic loading of the various system components. Even if the assumed splits are off by 50%, sufficient margins exist in the Remote Acquisition Units (RAU) to accommodate the required rearrangements.

Chart B presents the requirements for RAU resources relative to each experiment. By computing the data rates resulting from these requirements and entering these in chart A, a total requirement placed on the CDMS data input/output capability can be obtained. This results in a maximum requirement independant of any experiment operations scheduling and will immediately indicate whether or not there is a possibility of problems. The summation of the RAU Flexible and Serial Input Rates of columns one and two on chart 2A results in approximately 51 kilobits as the maximum possible input rate required and presents no problems to the CDMS.

The data presented in the RAU/HRM column of chart A is greatly in excess of what the final requirements should be due to assumptions utilized in developing this set of data. The RAU/HRM Rate column represents that portion of the experiment data which must be downlinked in order to monitor the experiments health, status, and operation. Due to the absence of requirements relative to this type of data on most experiments, the assumption that all data of ten samples per second and less would be downlinked. Since this assumption again places a maximum requirement on the system, establishment of the final and real requirement can only serve to expand the comfortable system margins which are currently projected.

The same assumption was utilized relative to the PCMMU data which represents that data required by the orbiter for monitoring experiments. Once the complete requirements are determined, these rates will also drop although the current projection of 10 kilobits presents no CDMS problem.

Where specific requirements were not available relative to the experiment commands from the RAU, the assumption was made that pulsed commands were required. Thus if an experiment required two (2) on/off commands, this was interperted as four (4) commands to satisfy the functions. The number of commands required for some of the experiments as shown on the requirements assessment chart C therefore may not agree with other data sources.

Several assumptions were made relative to the SEPAC (NS002) experiment. A split between the module and pallet was assumed for the sixty-two analog measurements and discrete commands were assumed for experiment control. Also, since the experiment requires DEP loading and interchange of data during operation, a serial input to the CDMS was assumed for request and control purposes.

Assumed requirements relative to other experiments were commands to NS003 for experiment equipment activation and control and for motor control on NS004. It is probable that other experiments such as NA009 and NT011 will also require some command controls. This, however, will be well within the system capability.

The RAU assignment charts list the various experiments and associated requirements which have been allocated to each RAU. Designations of 1M, 2M, 3M and 4M have been utilized relative to the module RAU's and the pallet RAU's have been designated 1P, 2P and 3P.

For the most part, experiment locations and experiment CDMS support requirements could be matched without difficulty. The one exception was the number of serial command channels required of RAU 3M which must be satisfied by utilizing the unused channel of RAU 2M located across the aisle. This configuration should not be difficult from an integration and checkout viewpoint nor provide any restrictions from an operational sense.

In order to derive the CDMS RAU input/output loading assessment, the mission timeline was broken into fourteen segments labled A thru N or sheets 1C and 2C. The segments result in a smoothed assessment of data rates and can be utilized to highlight areas which might need a more detailed assessment of operating requirements. However, from the standpoint of RAU activity and the requirements of

General Measurement Loop (GML) operations necessary to support the experiments, no problems were encountered even with the excessively stringent requirements indicated in segments B, H and I. Segment H shows the majority of experiments operating and still leaves an approximate 50% margin on RAU activity.

By utilizing RAU assignment coding in preparing the activity matrix on sheet C of the requirements assessment, a rough idea can be obtained relative to powered down operation of the RAU's. Although this is a rough assessment, segment A reveals no requirement for RAU's 2M, 4M, 1P, and 3P for the first 12 hours of the mission. Should RAU power consumption become a critical item, a more detailed assessment by other methods would be required.

EXP	LOCATION M/P	RAU FLEX RATE KBS	RAU SERIAL RATE KBS	RAU/HRM RATE KBS	PCMMU RATE KBS		HRM RATE KBS	HRM CHANNELS	RAU	VIDEO	ANALOG
1NS001	M/P	0.32 / .176	.612	.720	.720		120	1 (1)	2M / 3P		
1NS002	M/P	.128 / .368	.064	.560	.560		510	1	2M / 3P	✓	
1NS003	M	–	.096	.096	.096		1.0 300	2	2M	✓	
1NS004	P	.024	–	.024	.024		–		3P		
1NS005	P	.680	–	.680	.680		–		3P		
1NS006	M	–					–				
1NS007	M	–					–				
1NA008	P	.048	.128	.176	.176		–		3P		
1NA009	M	.158	–	.158	.158		16 1×10^4	2	1M		
1NT011	M	3.376	.064	3.44	.240		–		1M		
1NT012	M	–					–		1M		
VFI	M/P	.020 /	.064 /	.084			64 64 / 16	3	1M		
1NS100	M						2 50	2	4M	✓	
1ES013	M/P	.034 / .169	4.48 / –	.203	.203		51.2	1	3M / 2P		
1ES014	P	.012	–	.012	.012		–		1P		
1ES015	P	.009	.896	.905	.905		–		1P		
1ES016	P	.072	.144	.216	.216		–		2P		
1ES017	P	.102	.064	.166	.166		–		1P		
1ES018	M	.064	.512	.576	.576		0.5 102 (2)	2	3 M		
1ES019	P	–	25.6	–	–		224	1	1 P		

(1) VARIABLE RATE
(2) COUNTINGENCY ONLY

ASSESSMENT 1A

INPUTS									OUTPUTS					
ANALOG			DISCRETE			SERIAL			DISCRETE			SERIAL		TIME
1	10	100	1	10	100	1	10	100				NO	RATE	
4 / 22			–			32			8 / 40			1		✓
16 / 46			–			4			6 / 2			1		✓
–			–			6			8					
1			16			–			10					
5	8		–			–			13					
–			–			–			–					
–			–			–			–					
6			–			8			4			✓		
16			30			–			–					
2	2	4	–			4			–					
–			–			–			2			1		
–			20 / –			4 / –			34 / –					
–						–			–					✓
4 / 18			2 / 25				28 /		4 / 12			1 / –		1 /
1			4			–			2			1		✓
1			1			6	5		4			1		✓
9			–			9			4			1		1
9				3		4			8			1		✓
8			–			32			9			1		✓
–			–					16	7			1		1

ASSESSMENT 1B

RAU/GML ASSESSMENT

0	12	32.5	52.3	54.5	56.6	62.5	73.5	81.0	97.4	117	122.5	136.8	148		
A	B	C	D	E	F	G	H	I	J	K	L	M	N		
	2M/3P											2M/3P			
	2M/3P	2M/3P				2M/3P				2M/3P					
							2M					2M			
	3P												3P		
		3P	3P				3P		3P			3P			
								3P							
					1M			1M							
		1M		1M											
		1M				1M			1M						
1M													1M		
	4M	4M		4M		4M						4M			
	3M/2P					3M/2P		3M/2P							
	1P							1P							
	1P														
						2P		2P							
	1P	1P				1P	1P		1P		1P				
	3M							3M							
	1P			1P			1P	1P							

ASSESSMENT 1C

ORIGINAL PAGE IS
OF POOR QUALITY

EXP	LOCATION M/P	RAU FLEX RATE KBS	RAU SERIAL RATE KSB	RAU/HRM RATE KSB	PCMMU RATE KSB		HRM RATE KBS	HRM CHANNEL	RAU	VIDEO	ANALOG
1ES020	M / P	.006 / .006			.012		1×10^3	1	3-4M / 2P		
1ES021	P	.065	.016	.081	.081		–		2P		
1ES022	M		.016	.016	.016		–		3M		
1ES023	P	.120	.128	.248	.248		42	1	2P		
1ES024	P	.031		.031	.031		–		1P		
1ES025	M										
1ES026	M										
1ES027	M / P	.026 / .026		.052	.052		–		2M / 1P		
1ES028	M										
1ES029	P	.035		.035	.035		–		1P		
1ES030	M										
1ES031	M										
1ES032	M										
1EA033	M	.128	.128	.256	.256		–		2M		
1EA034	M / P	– / .040	1.12 / 1.12	1.12	1.16		300 3.2×10^4	2	3M / 2P		
1ES200/201	M	.994	6.80	1.994	.994		2.56	1	4M	✓	
1ES300	M	.010	2.08	2.09	2.09		–		4M		
SUN SENSOR	P	.200		.200	.200				2P		
HORIZON SENSOR	P	.008	.128	.136	.136				3P		
		6.967	44.160	14.275	10.127		13016.7				
		51.127									

ASSESSMENT 2A

INPUTS									OUTPUTS					
ANALOG			DISCRETE			SERIAL			DISCRETE			SERIAL		TIME
1	10	100	1	10	100	1	10	100				NO	RATE	
–			6/6			–			15/1			1/–		
7			9			1			18					
–			–			2			2			1		
15			–			8			6			1		✓
2			15			–			3					
3/3			2/2			–			2/2					
4			3			–			2					
16			–			8			3			1		✓
–/5			–				7/7		10/15			1/1		1/–
4	4/8		–/2				32/8		–/3			1/1		1/–
–			10				13					1		✓
	1			12					2					
1							8		2					

ASSESSMENT 2B

ORIGINAL PAGE IS
OF POOR QUALITY

RAU/GML ASSESSMENT

0	12	32.5	52.3	54.5	58.8	62.5	73.5	81.9	87.4	117	122.5	136.8	148		
A	B	C	D	E	F	G	H	I	J	K	L	M	N		
3M / 2P	3M / 2P	3M / 2P				3M / 2P	3M / 2P								
								2P							
		3M	3M												
	2P			2P		2P	2P	2P							
	1P						1P								
	2M / 1P												2M / 1P		
	1P												1P		
	2M														
								3M / 2P	3M / 2P						
	4M											4M			

ASSESSMENT 2C

RAU 1M

EXPE-RIMENT	HRM-CHAN-NELS	DISCR. DATA-CHNLS	ANAL. DATA-CHNLS	PCM-DATA-CHNLS	ON/OFF CMD-CHNLS	PCM CMD-CHNLS	UTC + UTCU-CHNLS
NA009	2	30	16	–	–	–	–
NT011	–	–	8	1	–	–	–
NT012	–	–	–	–	2	1	–
VFI	2	20	–	1	34	–	–
TOTAL	4	50	24	2	36	1	–

RAU 2M

EXPE-RIMENT	HRM-CHAN-NELS	DISCR. DATA-CHNLS	ANAL. DATA-CHNLS	PCM DATA-CHNLS	ON/OFF CMD-CHNLS	PCM CMD-CHNLS	UTC + UTCU-CHNLS
NS001	1 VARIABLE RATE	–	4	1	8	1	1
NS002	1	–	16	1	6	1	1
NS003	2	–	–	1	8	1	–
ES027	–	–	3	–	2	–	–
EA033	–	–	16	1	3	1	1
TOTAL	4	0	39	4	27	4	3

= ASSUMED

ORIGINAL PAGE IS
OF POOR QUALITY

RAU 3M

EXPE-RIMENT	HRM-CHAN-NELS	DISCR. DATA-CHNLS	ANAL. DATA-CHNLS	PCM-DATA-CHNLS	ON/OFF CMD-CHNLS	PCM CMD-CHNLS	UTC + UTCU-CHNLS
ES013	1	2	4	1	4	1	1
ES018	2*	–	8	1	9	1	1
ES020	1	6	–	–	15	1 (1)	–
ES022	–	–	–	1	2	1	–
EA034	2	–	–	1	10	1	1
TOTAL	6	8	12	4	40	5	3

*COULD BE ONE LESS
(1) REQUIREMENT SATISFIED BY RAU 4M

RAU 4M

EXPE-RIMENT	HRM-CHAN-NELS	DISCR. DATA-CHNLS	ANAL. DATA-CHNLS	PCM DATA-CHNLS	ON/OFF CMD-CHNLS	PCM CMD-CHNLS	UTC + UTCU-CHNLS
ES020	–	–	–	–	–	1	–
NS100	1	–	–	–	–	–	1
ES200	1	–	8	–	–	1	1
ES201	–	2	8	2	3	1	–
ES300	–	10	–	1	–	1	1
TOTAL	2	12	16	3	3	3	3

EXPE-RIMENT	HRM-CHAN-NELS	DISCR. DATA-CHNLS	ANAL. DATA-CHNLS	PCM-DATA-CHNLS	ON/OFF CMD-CHNLS	PCM CMD-CHNLS	UTC + UTCU-CHNLS

RAU 1P

EXPE-RIMENT	HRM-CHAN-NELS	DISCR. DATA-CHNLS	ANAL. DATA-CHNLS	PCM DATA-CHNLS	ON/OFF CMD-CHNLS	PCM CMD-CHNLS	UTC + UTCU-CHNLS
ES014	–	4	1	–	2	1*	1
ES015	–	1	1	2*	4	1	1
ES017	–	3	9	1	8	1	1
ES019	1	–	–	1	7	1	1
ES024	–	15	2	–	3	–	–
ES027	–	2	3	–	2	–	–
ES029	–	3	4	–	2	–	–
	1	33	20	4	28	4	4

* COULD REDUCE BY ONE

C-4

ORIGINAL PAGE IS
OF POOR QUALITY

RAU 2P

EXPE-RIMENT	HRM-CHAN-NELS	DISCR. DATA-CHNLS	ANAL. DATA-CHNLS	PCM-DATA-CHNLS	ON/OFF CMD-CHNLS	PCM CMD-CHNLS	UTC + UTCU-CHNLS
ES013	–	25	18	–	12	–	–
ES016	–	–	9	1	4	1	1
ES020	–	6	–	–	1	–	–
ES021	–	9	7	1	18	–	–
ES023	1	–	15	1	6	1	1
IEA034	–	–	5	1	15	1	–
SUN SENSOR		12	1	–	2	–	–
RADIATION MONITOR	1	–	–	–	–	–	–
	2	52	55	4	58	3	2

RAU 3P

EXPE-RIMENT	HRM-CHAN-NELS	DISCR. DATA-CHNLS	ANAL. DATA-CHNLS	PCM DATA-CHNLS	ON/OFF CMD-CHNLS	PCM CMD-CHNLS	UTC + UTCU-CHNLS
NS001	–	–	22	–	40	–	–
NS002	–	–	46	–	2	1	–
NS003		–	–		–	–	–
NS004	–	16	1	–	10	–	–
NS005	–	–	13	–	13	–	–
NA008	–	–	6	1	4	1	–
HOR SENSOR	–	–	1	1	2	–	–
		16	89	2	71	2	0

9.10 NASA EXPERIMENT REQUIREMENTS

This appendix lists, by experiment, the requirements for data systems support from each experiment. These requirements were derived from the latest ERD's, and discussions with individual investigators. The requirements listed herein were used to establish the data system configuration assessed by this study.

1NS001

NAME: Imaging Spectrometric Observatory

LOCATION: Experiment located on pallet with electronics in the module.

OUTPUTS: From pallet to RAU
(1) 22 Analogs @ 1 SPS

From Module to RAU
(1) 4 Analogs at 1 SPS
(2) 32-16 bit status words
(3) Digital bit stream to HRM with one of three bit rates as defined by the functional objective. 1.5 KBPS, 15 KBPS, 120 KBPS

INPUTS:
(1) 128 word/16 bit command table to be loaded from MMU to experiment DEP prior to each operation
(2) Time - GMT and 1024 KHz plus update.
(3) Four ON/OFF commands in the module.
(4) Twenty ON/OFF commands on the pallet.

DISPLAY:

Alpha numeric display at the DDU will be required for the above 26 Analog outputs only in the case of a malfunction.

The experimenter is providing his own display GSE in the POCC. The input required is the experiment HRDM output and orbiter attitude data.

FUNCTIONAL OBJECTIVES:

NS001A	Initial Turn ON and Checkout, 1.5 KBPS HRM input
NS001B	Weak Nocturnal low altitude emissions 1.5 KBPS
NS001C	Medium intensity nocturnal emissions 1.5 KBPS
NS001D	Downward looking dayglow 120 KBPS
NS001E	Dayglow atomic emissions 15 KBPS
NS001F	High altitude nocturnal emissions 15 KBPS
NS001G	Twilight emissions 15 KBPS

NS001H	Contaminant study: resonance flourescence 120 KBPS
NS001I	Contaminant study: spacecraft atmosphere induced emissions 15 KBPS
NS001M	Electron accelerator induced emissions 120 KBPS To be run with NS002H, NS002I, NS002J, NS002K.
NS001N	For EUV stellar sources 15 KBPS
NS001J	Calibration study 15 KBPS
NS001K	Dayglow emissions 1.5 KBPS
NS001L	Dayglow scans 1.5 KBPS

OPERATION:

A normal observation run may contain a thermal warm-up period of 30 minutes and one or more observing sequences. The length of a typical run is approximately 60 minutes, depending on the FO and the number of observing sequences. Observing sequences may run from 10 to 40 minutes.

COMMENTS:

This experiment is controlled by its DEP in normal operation i.e., it will operate in the hands off mode. The DEP command table is loaded prior to early operation through the CDMS. The command table can be transmitted from the POCC in a contingency situation.

1NS002

NAME: Space Experiment with Particle Accelerator (SEPAC)

LOCATION: Manual Control Panel - Module
Experiment and DEP - Pallet

OUTPUTS:

(1) 512 KBPS to HRM any time experiment is on.
(2) 62 one sample/sec analog flexible inputs to RAU (16 module, 56 pallet) any time experiment is on. Routed to DDU for onboard CRT display. (Graphics required)
(3) 4.2 MHZ TV downlink any time experiment is on.
(4) 4.2 MHZ wideband to analog recorder any time experiment is on. To be dumped later as time line allows. (Selected Samples)
(5) TV monitor onboard. Cameras provided by experimenter. Monitor in experiment pack.

INPUTS: (RAU)

(1) Time GMT and 1024 KHZ plus update.
(2) DEP load from MMU-1K-16 bit words prior to each experiment.
(3) Software transfer - 200 words once per experiment.
(4) DEP parameter change from keyboard for contingency. - 1K words.
(5) Experiment deactivation - 1K words once per experiment.
(6) Aspect information - 8K words on command.

(POCC)

Experimenter will provide his own GSE; however POCC must strip out 62 analog status measurements for CRT display from the HRM bit stream.

DISPLAY: See OUTPUTS above

FUNCTIONAL OBJECTIVES:

The data output are the same for all functional objectives. This experiment operates with 1NS001, 1NS003, ES018 and ES019 within the time bracket 120 to 135.

2

OPERATION:

A typical operation sequence will run about 30 minutes ranging from 14 to 34 minutes. System checkout requires 34 minutes which will be added to the total time of the experiment run when required. It is assumed that checkout will be performed prior to each experiment run unless experiments are run back to back.

COMMENTS:

The SEPAC experiment has its own experiment rack in the module for some control and display. The module CRT and keyboard will also be used for graphics display and loading the DEP.

1NS003

NAME: Atmospheric Emission Photometric Imager
on Low Light Level TV Observations

LOCATION: Experiment on pallet, Electronics in module

OUTPUTS: (1) 1KBPS to HRM
(2) 300 KBPS to HRM
(3) 4.2 MHZ TV Downlink to POCC.
These outputs are required in all modes although not necessarily full time.

INPUTS:
(1) DEP Load - Transfer 2K words (100 wds/sec) from keyboard to DEP per operation.
(2) Experiment Activation - 1K words from MMU to DEP. Once per operation. Routed to DDU, also.
(3) Aspect Data - 180 words/sec., 8K words. Continuous from MMU to DEP.
(4) Experiment Deactivation - 1K words from MMU to DEP once per operation. Routed to DDU also.
(5) Software Transfer - Contingency if DEP software fails. 32K words from MMU to DEP. (1MBPS).

DISPLAY: Module CRT-ASCII Messages.
Module TV Monitor
POCC displays are same as onboard display, plus digital displays of photon counting array and housekeeping.

FUNCTIONAL OBJECTIVES:
Data outputs are the same for each functional objective. Experiment operates with NS002, in time period 120-135.

OPERATION:
A typical experiment operation requires about 1 hour and 30 minutes including time for thermal control. It is assured that 30 minutes per experiment would be required if run back to back.

COMMENTS:

This experiment has its own DEP which controls the experiment during normal operation. Contingency commands are required.

1NS004

NAME: Ion States of Solar and Galactic Cosmic Rays

LOCATION: Pallet

OUTPUTS: From pallet to RAU to CDMS to HRM
Encoder 16 bit discretes every 15 sec.

INPUTS: From CDMS to RAU to Experiment
ON/OFF signals 8 discretes
ON/OFF signal 2 discretes
(Power ON and power OFF)

DISPLAY: No onboard display required
No RT POCC display required
Off-line POCC data storage/examination

FUNCTIONAL OBJECTIVES:
This experiment has one FO.

OPERATION:
See Comments.

COMMENTS:

Experiment timeline as continuous operation. Will be turned off at end of operation by ECAS. Operation and control completely by ECAS. No on-board intervention required once experiment begins operation.

1NS005

NAME: **Far UV Astronomy Using the FAUST Telescope**

LOCATION: Pallet

OUTPUTS: From experiment on pallet to RAU
5 Analog measurements at 1 SPS
8 Analog measurements at 10 SPS

INPUTS: From keyboard to experiment via CDMS/RAU
13 Discrete commands

DISPLAY: All thirteen (13) outputs will be displayed onboard by the DDU and at the POCC in real time.

FUNCTIONAL OBJECTIVES:
NS005A, NS005B
Each FO will output the same thirteen signals. The Imaging Spectrometer will be operated along with this experiment. Its FO is NS001N.

OPERATION:
A normal observing run will contain one or more observing sequences. Typically, a normal run will last for approximately 15 minutes with observing sequences of up to five minutes.

COMMENTS:

This experiment is controlled completely by PS with keyboard commands, DDU display and RT voice from data monitoring at the POCC.

1NS006

NAME: HZE (High-Charge and Energy) Particle Dosimetry

This experiment does not levy any requirements on the data system, and has no connection thereto.

1NS007

NAME: Persisting Circadian Rhythms

This experiment does not levy any requirements on the data system, and has no connection thereto.

1NA008

NAME: Active Cavity Radiometer (ACR Solar Irradiance Monitor)

LOCATION: Experiment will be mounted on the pallet, and will view along the +Z Spacelab axis.

OUTPUTS: 6 Analog @ 1 SPS
1 Digital @ 120 BPS (Serial Digital)

INPUTS: 2 Discrete command signals.
1 Digital command signal.
Commands and clock from RAU to ACR experiment.

DISPLAY: POCC display devices: 1 CRT and 1 line printer.

FUNCTIONAL OBJECTIVES:
NA008A, NA008B. Each FO will output the same signals.

OPERATION:
One experiment operating cycle lasts 10 minutes, typically.

COMMENTS:

Real time transmission is preferred but NRT transmission is acceptable.

All ACR control commands for normal operations will be stored in and executed from Spacelab CDMS timeline software. Only override commands will be sent by the PI from POCC keyboard.

1NA009

NAME: Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS)

LOCATION: Optical Sensor mounted in Spacelab top airlock; Electronics mounted in module standard equipment rack.

OUTPUTS: From Optical Sensor in Airlock to Electronics Package in module to HRM:

Science Data

1 Digital @ 10^7 BPS

Diagnostic Data

1 Digital @ 1.6×10^4 BPS

From Optical Sensor in Airlock to Electronics Package in module to Experiment RAU:

Engineering Data:

16 Analog Channels sampled at 10 SPS

30 Discrete Data Signals sampled at 10 SPS

INPUTS: From keyboard through I/O and RAU to experiment:

2 Discrete Command Signals

1 Digital Command Signal

DISPLAY: Analog Engineering Data: POCC and Onboard Display

Digital Science Data: POCC

Digital Diagnostic Data: POCC Display

Discrete Engineering Data: POCC and Onboard Display

FUNCTIONAL OBJECTIVES:

NA009A, NA009B, NA009C, NA009D and NA009E

In each FO, the experiment will output the same set of data signals. Experiment 1ES013 will operate concurrently with FO's NA009D and NA009E.

OPERATION:

The ATMOS instrument views the sun through the stratosphere, and measures the spectral absorption of solar energy. Each data taking run is initiated prior to the sun emerging from or disappearing behind the earth. The resulting "interferograms", after processing, provide absorption spectra for scientific analysis. Each cycle is typically three minutes in duration. However, a run may consist of different numbers of cycles.

COMMENTS:

The data taking sequence will be preprogrammed in the CDMS, with provisions for changes by command from the ground, or manual operation by the payload specialist using the ATMOS control/display panel.

PI desires photographic record (using hand-held camera) of sun during sunrise or sunset data taking periods.

INT011

NAME: Tribological Experiment in Zero Gravity

LOCATION: Module - port side

OUTPUTS: From experiment in module to RAU:
4 Analogs @ 100 SPS (Displacement Transducers)
1 Analog @ 1 SPS (Temperature)
1 Analog (D. C.) @ 10 SPS (Camera Shutter)
1 Analog @ 10 SPS (Flywheel RPM)
1 PCM @ 64 BPS (Low "G" Channels)
1 Analog @ 1 SPS (Low "G" Accelerometer Block Temp.)

INPUTS: None.

DISPLAY: All outputs will be displayed on DDU. POCC display requirements TBD.

FUNCTIONAL OBJECTIVES:
NT011A and NT011B.

OPERATION:
The fluid spreading experiment cycle lasts for approximately 20 minutes. However, data are collected for less than 2 minutes of each cycle.

COMMENTS:

Science data is on film. Control independent of CDMS.

INT012

NAME: Geophysical Fluid Flow Cell

LOCATION: Module

OUTPUTS: None. Self contained experiment

INPUTS: From RAU to DEP
GMT
ON/OFF Power discretes

DISPLAY: Does not use DDU or RT POCC

FUNCTIONAL OBJECTIVES:
NT012 is this experiment's only functional objective.

OPERATION:
This experiment is self controlled and required only to be turned on. It will automatically sequence itself. Normal run cycle is six hours.

COMMENTS:

Data will be recorded with a camera system. Experiment is operated and controlled by DEP. DEP will not require loading. Experiment has its own control panel.

1NS100

NAME: Life Sciences Mini-Lab

LOCATION: Module

OUTPUTS: 1NS101-Television 4.2 MHz
1NS102-Television 4.2 MHz
50 KBPS to HRM
1NS104-2 KBPS to HRM

INPUTS: Time - 1024 KHZ plus update
This is the only RAU interface for 1NS100
and is required for 1NS102 and 1NS104.

DISPLAY: Onboard
1NS101-CRT (TV) PI provided.
1NS102-Storage oscilloscope PI provided
1NS104-Oscilloscope, PI provided

POCC
1NS101-CRT
1NS102-Strip Chart, TV, Storage Scope.
1NS104-Graphics display

FUNCTIONAL OBJECTIVES:
Functional Objectives have data requirements as defined any time they are in operation. Experiments 1NS102 and 1NS104 operate with 1ES200.

OPERATION:
1NS101 operates continuously. TV downlink is required for a maximum of 30 minutes each 24 hours. 1NS102 requires about one hour and 30 minutes of data collecting per operation.

COMMENTS:

1NS100 contains seven separate experiments, 1NS101 through 1NS107. Only 1NS101, 1NS102 and 1NS104 require inputs and outputs to the CDMS as described above.

I.1 GENERAL

This appendix describes the operating modes, format structure, format change, control and monitoring and data flow considerations for the high rate multiplexer/high rate demultiplexer (HRM/HRDM) combination.

I.2 HRM

I.2.1 Functional Description

I.2.1.1 Description of the Block Diagram. The block diagram, figure I-1, shows in detail all interfaces and all major functional blocks of the HRM. The general data flow direction is from left to right. The interfaces are:

- 22 inputs
- Five outputs
- Two direct channels.

I.2.1.2 Data Flow. The different data sources are:

- Experiments (16)
- Recorders (2)
- Voice channels (3)
- Onboard computer (2)
- GMT (1)
- Experiment direct access channels (2)

The first four types of inputs have FIFO's as interface elements, while the last two types deliver data into the data stream. Some interfaces include transcoders:

- The onboard computers need BIU's
- The payload recorder needs a Bi-phase to NRZ-L decoder
- The voice channels are delta modulated
- The GMT needs an IRIG-B to NRZ-L decoder.

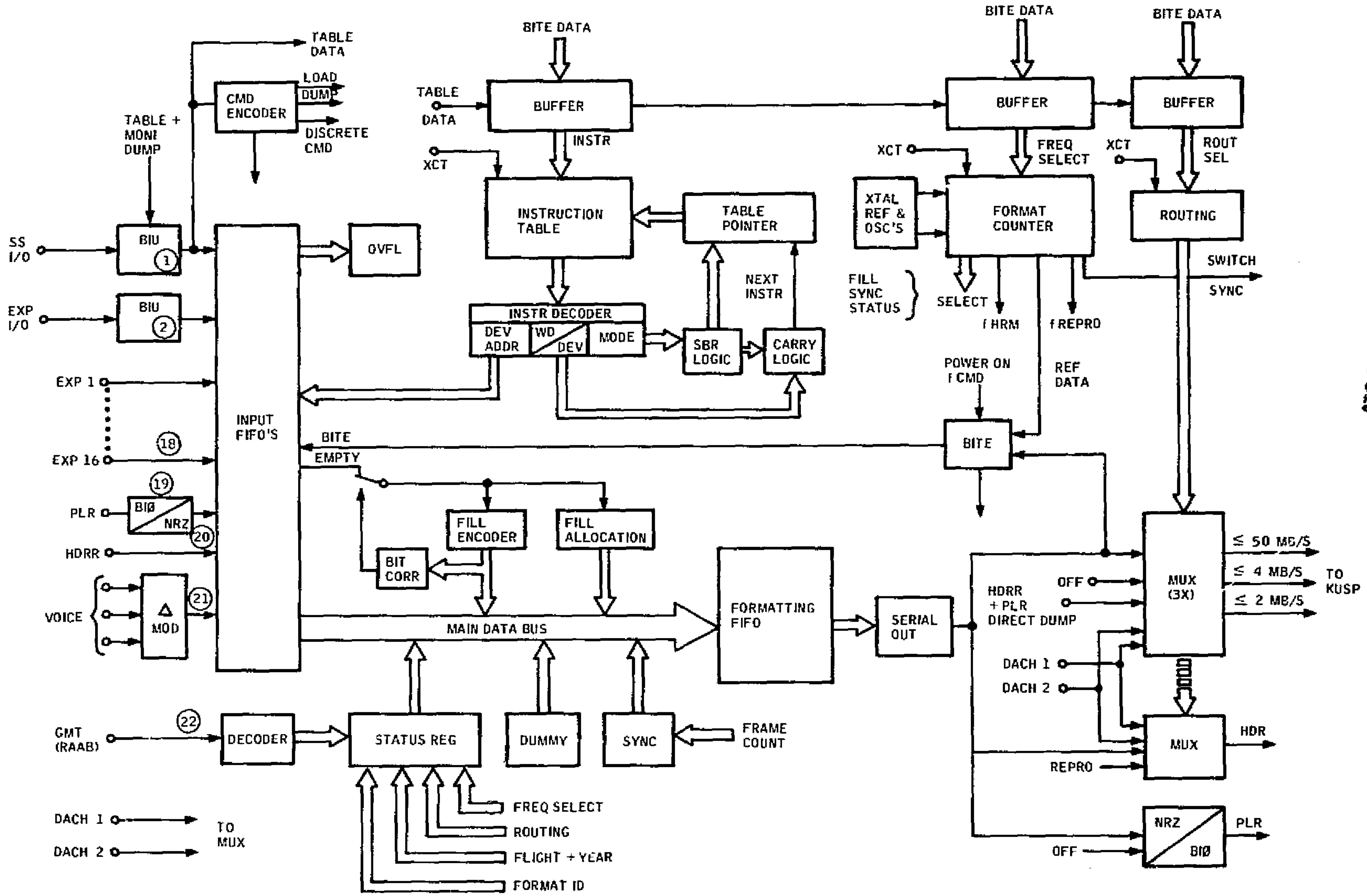


Figure I-1 HRM Block Diagram

AA10914(C)-9

The data stream on the main data bus is controlled by both the controller and the format counter. The format counter has the highest priority, because it defines the actual format. It is responsible for the correct timing of:

- Synch word
- Status word
- Fill word.

The controller is second in the hierarchy. It calls data from the diverse user's FIFO's and composes a data stream on the main data bus, which is 17 bits (16 data + 1 empty) wide and ends at the formatting FIFO.

The 16 data bits are loaded into the formatting FIFO if the 17-bit (empty) signal is low. If it is high (indicating that no new data is available from the called input FIFO), the write pulse of the formatting FIFO is inhibited and a one is shifted into the fill encoder and the fill allocation. Both fill registers form an BCH (31,16) encoder word.

The formatting FIFO has the capacity to buffer a complete line (36 words). The output is controlled by the format counter and works at a predetermined rate, which is 16 times slower than the output rate f_{HRM} of the following parallel/serial converter (= serial outstage in the diagram).

The output signal of this stage is distributed to the built-in-test-equipment (BITE), and to the diverse multiplexers of the KUSP, HDRR and PLR. The multiplexers can access also data directly from HDRR, PLR and from experimenters (DACH).

The BITE is turned on either by telecommand or by POWER-ON RESET. In this mode, all input FIFO's generate a bit pattern which is compared with the reference data from the format counter. Each error in the data stream on the main data bus is monitored.

The user FIFO's are called according to a program, which is stored in the instruction table. The table is loaded parallel with an execute (XCT) signal with data, which is shifted serially into the buffer registers. The table data is stored in the S/S computer and transferred via S/S BIU into the HRM. The table data is interpreted in the instruction decoder; the subroutine (SBR) logic determines the mode of communication.

Parallel to the table data, the status data is loaded into format counter (f_{HRM} and f_{REPRO}) and into routing register.

The status and the GMT are interfaced in the main data stream at predetermined time slots. Much housekeeping data is monitored (MONI) and transferred back via S/S BIU to the S/S computer.

I.2.2 HRM Operating Modes[1]. The modes of operation are:

- Normal mode, with independent multiplexer (MUX) data routing to KUSP, PLR and HDRR outputs
- Power-Saving Mode, with parts of the HRM switched off
- BITE Mode, with all multiplexer data inputs switched to an internal stimulus signal.

I.2.2.1 Normal Mode. The three signal types are:

- MUX data (input data buffered in FIFO's and formatted)
- DACH data (direct experiment data)
- Direct dump data (from HDRR or PLR)

They are routed individually according to the configuration status stored in word 17 and word 18 of the formatting table.

The HRM operates in various modes to route user data directly or in multiplexed form to the KUSP[2] or to the recorders. The HRM can be set to generate different formats which define the share of transmission bandwidth assigned to each user. The basic modes for the normal mode of operation are:

a. Real-time transmission of multiplexed data

b. Recording of multiplexed data

c. Playback of recorded data via HRM

d. Direct dump of recorded data to KUSP

e. Bypass of the MUX for direct transmission of experiment data

f. Bypass of the MUX for direct recording of experiment data

g. HRM switched off.

Other modes require simultaneous operation of the following basic modes:

- a+b
- a+c

- a+d
- a+f

The following shows the routing capability of the HRM:

OUTPUT	INPUT
KUSP (2 MHz)	OFF/MUX/HDRR/PLR
KUSP (4 MHz)	OFF/MUX/HDRR/PLR
KUSP (48 MHz)	OFF/MUX/HDRR/Direct Ch. No. 1+2/PLR
HDRR	OFF/MUX/Direct Ch. No. 1+2
PLR	OFF/MUX

The PLR can be dumped directly to the KUSP after its playback data is transcoded to NRZ-L. Routing of direct access channel to the PLR is not foreseen in the reference system because it is assumed that the users of the direct channels exceed the PLR capacity.

It is up to operations personnel to program the desired routing; false routing is not inhibited and cannot cause permanent degradation.

I.2.2.2 Power-Saving Mode. There are 3 power saving modes, PS0, PS1, and PS2 as follows.

- Group 1 experiments (No. 1 to 8 inclusive) are switched off by PS1
- Group 2 experiments (No. 9 to 15 inclusive) are switched off by PS2 (not breadboard)
- The complete multiplexer section and both groups of experiments are switched off by PS0.

The normal mode can be restored only after switching off the HRM power. The following paragraphs show which functional groups are affected by which command:

A. Power Saving Effects in Breadboard

1. PS1. Experiments No. 1-4, boards A1 + A2.
2. PS0
   - Experiments No. 1-4, boards A1 + A2
   - PLR, board B

- Intercom, board D
- GMT decoder, board E
- Format FIFO + BCH Encoder, board H
- I/O FIFO, board M.

B. Power Saving Effects in QM

1. PS1. Experiments No. 1-8.
2. PS2. Experiments No. 9-15.
3. PS0
   - All experiments (No. 1-15)
   - PLR
   - Both I/O-FIFO's (S/S and Experiment)
   - Experiment-I/O-command decoder
   - Intercom
   - GMT-decoder
   - Format FIFO + BCH-encoder
   - P/S converter, BITE
   - Controller.

I.2.2.3 BITE Mode[1]. In BITE mode, all input data channels are switched over to an internal generated data stream, generated by the BITE. The data stream is loaded into all input FIFO's, which are multiplexed as in the normal mode. At the serial output of the MUX section, the data stream is tested by the BITE for errors. The format table for the BITE format is a hardwired program, which is called by a discrete command BITE ON, or automatically after each HRM POWER ON transition after a POWER OFF period greater than 0.5 ms, or (in breadboard only) by a format identification code (1 1 1 1 1 1). This feature can be used to run the MUX in BITE mode with programmed formats and bit rates. The normal mode can be restored by loading a new format into the table register and sending an EXECUTE NEW FORMAT signal.

I.2.3 Format Structure

I.2.3.1 Overall Format Concepts. In the HRM/HRDM design, two format definitions are used[3]. The engineering format consists of 16 frames with 192 words each. Each frame contains a sync word and a status word. In the status word, the GMT information is transferred with eight bits subcommutated over 16 frames. The frame count is transferred with four bits in the sync word.

The user format consists of eight frames with 96 words. Each frame begins with the sync or the status word of the engineering format. The normal frame is composed of 6 lines × 16 words and is used for all frequencies except 48 MHz, for which the format is arranged in 8 lines × 12 words.

The two definitions are used to identify the contents of the HRM format. The engineering format is the definition of the overall structure, and the user format defines the contents of the format.

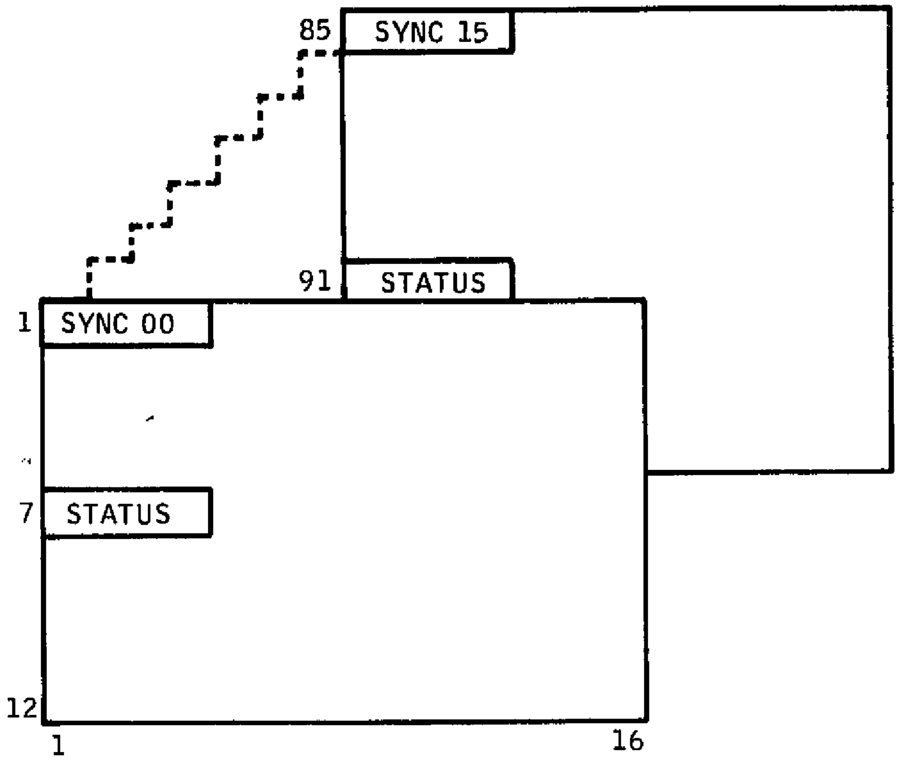
Figure I-2 shows the format structure for all binarily related bit rates from 0.125 Mb/s to 32 Mb/s. At 48 Mb/s, the width of both the engineering and user frames is reduced to 12 words and the length is increased to 16 lines for the engineering format and 8 lines for the user format. The format is output from left to right and top to bottom. Figure I-3 shows the eight frame user format structure for both the 16 column and 12 column cases.

I.2.3.2 HRM Format Structures. The formatting of data within the HRM system is performed according to a set of parameters stored in one of two random access memories (instruction tables). One table is the operating table and the other is free to accept a new set of instructions. The tables are exchanged synchronous to the format after an execution command has been received.

A. Format Programming. The programmer has to work only with the user format. He has the flexibility to assign each user's share of bandwidth with three types of priority:

- In mode 3 (highest priority) the number of user words is specified as words per line
- In mode 2 (lower priority) the number of user words is specified as words per frame and
- In mode 1 (lowest priority) the number of words is specified as words per format.

ENGINEERING FORMAT



USER FORMAT

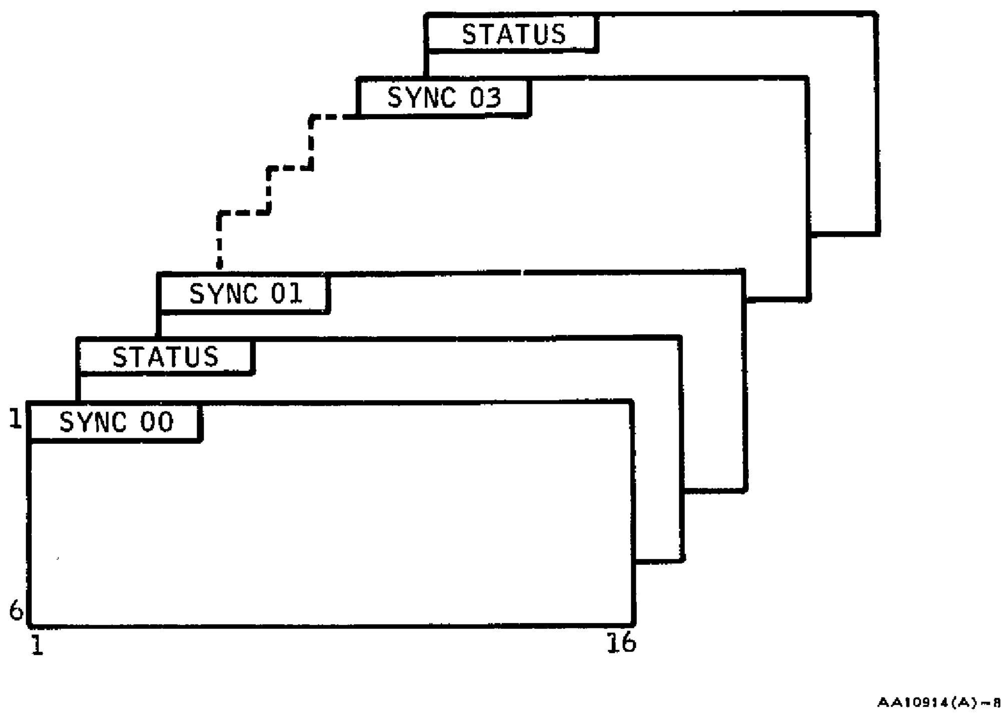


Figure I-2 Engineering and User Format

FORMAT STRUCTURE 1 IS USED FOR HRM OUTPUT BIT RATES OF 32 MB/S AND ALL LOWER OUTPUT RATES BEING BINARY RATIOS OF 32 MB/S.

FORMAT STRUCTURE 2 IS USED FOR THE 48 MB/S OUTPUT RATE ONLY, SINCE IT IS NOT BINARY RATIO OF 32 MB/S.

THE FRAMES ARE ORGANIZED IN 6 LINES AND 16 COLUMNS IN FORMAT STRUCTURE 1 AND IN 8 LINES AND 12 COLUMNS IN FORMAT STRUCTURE 2. THE LAST WORD IN EACH LINE IS OCCUPIED BY THE FILL WORD IDENTIFICATION. EVEN FRAMES START WITH A SYNC PATTERN, ODD FRAMES WITH A STATUS PATTERN.

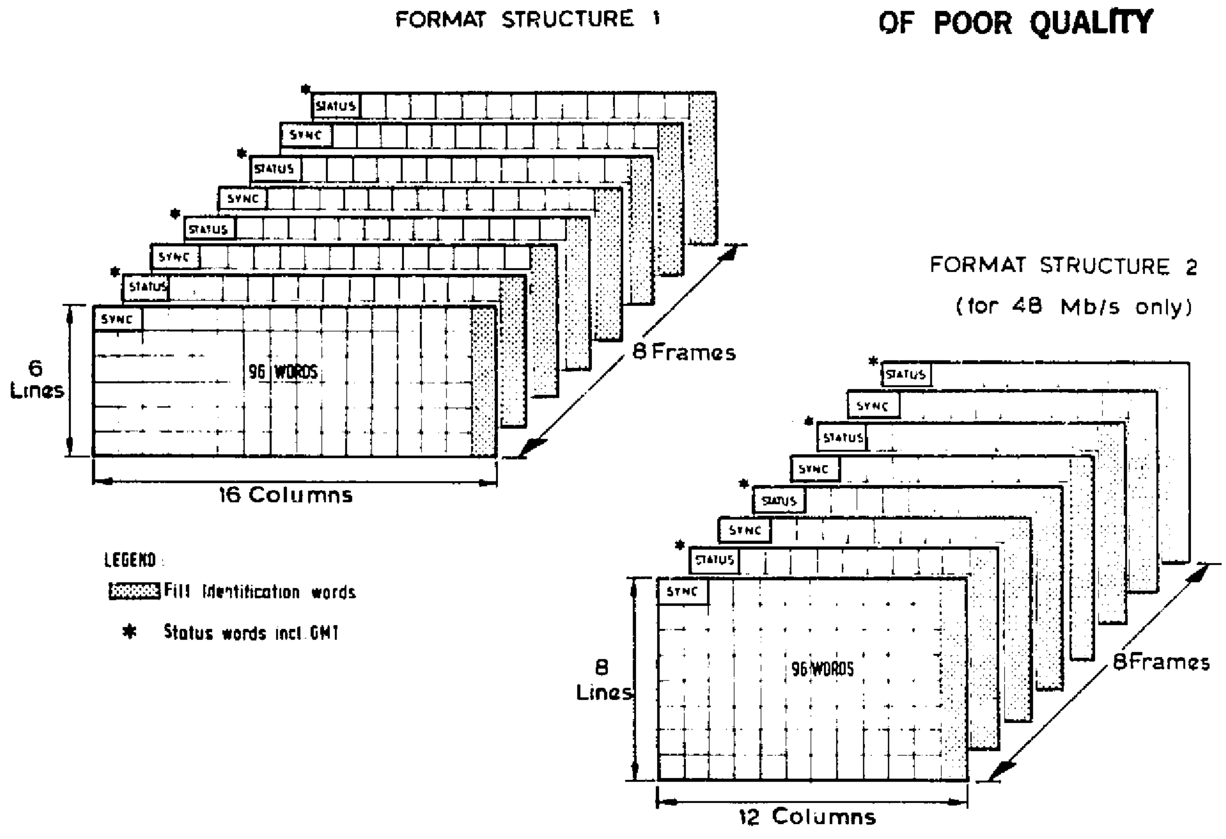


Figure I-3 HRM Format Structure

The formatting of user data is accomplished with a formatting table of 16 consecutive instructions. Each instruction word comprises 16 bits which serve to define two users and their share (number of words alloted to the user):

BITS	DEFINING
0,1	PRIORITY OF INSTRUCTION
2-6	FIRST USER
7,8	NUMBER OF WORDS OF FIRST USER
9,13	SECOND USER
14,15	NUMBER OF WORDS OF SECOND USER

With a set of 16 such instructions, the programmer can assign the bandwidth shares of each user. In addition to the 16 instruction words, the formatting table comprises two configuration status words (words 27 and 38). An example of programming is shown in table I-1.

B. Constraints. The HRM-controller offers high flexibility to the programmer, but some constraints are still present.

1. The instruction table must be programmed in a series of descending mode number; that is to say, first entries in the instruction table shall be assigned with Mode 3 instructions followed by Mode 2 and Mode 1 instructions.

2. An odd number of instructions with the same mode has to be increased by a SKIP instruction to give an even number.

3. The number of entries in a table is limited to 32.

4. Special attention should be paid to the last line (No. 18) in the table (instructions 31 and 32). It shall be assigned with Mode 0 (end of table) or Mode 1 instruction only. A mode 1 assignment to the last line has the following effects:

   a. If only instruction 31 is used and instruction 32 is a SKIP, the controller will execute instruction 31 until the end of a user format.

   b. If both instructions are used, the controller will execute both instructions in an alternating series.

   For QM, this feature will be extended, so that the last line could be assigned also with Mode 2 instructions.

TABLE I-1

PROGRAMMING EXAMPLE

INSTR WORD	MODE	USER ADDRESS	WORD/ USER	FREQ FRAME (KHZ)	BIT POSITIONS 01	23456	78	9	10	11	12	13	14	15	USER FREQUENCY SHARE (KHZ)	
1	3	HDRR (23)	4	1000	11	11101	00	0	0	1	0	1	0	0	E1	41,6
		PLR (20)	4	1000											E2	-
															E3	41,6
2	3	HDRR	4	1000	11	11101	00	1	1	1	1	1	1	1	E4	125
		SKIP (31)	1	-											E5	-
															E6	
3	2	EXP3 (3)	1	41,6	01	11000	11	0	0	0	1	0	0	1	E7	-
		EXP8 (8)	2	83,3											E8	83,3
															E9	-
4	2	EXP4 (4)	3	125	01	00101	10	1	1	1	0	1	0	1	E10	10,4
		HDRR	2	83,3											E11	-
															E12	-
5	2	INTERCOM (19)	3	125	01	11001	10	0	0	1	0	1	1	1	E13	16,7
		PLR	1												E14	-
															E15	-
6	2	EXP1 (1)	1	41,6	01	10000	01	1	1	1	1	1	1	1	E16	-
		SKIP	1	-											DUMMY	-
															INTERCOM	130,2
7	1	SS-I/O (21)	4	20,8	10	10101	00	0	1	1	0	1	0	0	PLR	1041,6
		EXP-I/O (22)	4	20,8											HDRR	2083,3
															SS-I/O	26
8	1	SS-I/O	1	5,2	10	10101	11	0	1	1	0	1	1	1	EXP-I/O	26
		EXP-I/O	1	5,2												

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

TABLE I-1 (CONT'D)

INSTR WORD	MODE	USER ADDRESS	WORD/USER	FREQ FRAME (KHZ)	BIT POSITIONS 01	23456	78	9	10	11	12	13	14	15	USER FREQUENCY SHARE (KHZ)
9	1	EXP10 (10)	2	10.4	10	01010	01	1	0	1	0	1	1	0	
		EXP13 (13)	3	15.6											HRM 4000.0
10	1	INTERDOM (19)	1	5,2	10	11001	11	1	1	1	1	1	1	1	
		SKIP	1	-											
11-16	0	SKIP	1	-	00	11111	11	1	1	1	1	1	1	1	
		SKIP	1	-											

INSTR WORD	INFORMATION		CODE	BIT POSITION FOR WORDS 17-18 (01 23456 78 9 10 11 12 13 14 15)	
17	SPARE		X	XX XXXXX XX 1 0 0 0 0 0 0	
18	F_{HRM}	4 MHZ	11	1101 100 000 11 00 00	
	F_{REPRO}	2 MHZ			
	KUSP1	OFF			
	KUSP2	MUX			
	KUSP3	OFF			
	HDRR	REPRO			

5. For BB only, it is necessary to assign in a format at least 1 instruction with Mode 1.

6. The HRM address for I/O units shall not be 00000, because this code is identical to the clear condition of the input register.

C. Formatting Example. In figure I-4, an example of a particular HRM format is given. Table I-2 shows the set of instructions defining this format. The nominal data rates allocated to each input channel as a result of this format are given in table I-3.

D. BITE Format. Figure I-5 shows the content of the BITE format which is the only preprogrammed format in the HRM.

NOTE: Words and lines are numbered from 1 and bits within a word are numbered from 0 (zero).

E. Experiment Bandwidth Selection. Table I-4 summarizes the experiment bandwidths made available by selecting appropriate format parameters.

I.2.4 HRM Control and Monitoring

I.2.4.1 Discrete Commands and Monitoring. Table I-5 lists all the commands and their verification except those of the BIU. Table I-6 lists all the BIU discrete commands and their verification by BIU status word response. Some of the information serves a monitor function only so they do not appear in the list as the result of any given commands.

Table I-7 lists the formatting and configuration status formats. The verification is not shown since these 18 words are read out exactly as they are loaded (see table I-7). Paragraph I.2.3 explains the use of the formatting information, and table I-4 lists all the possible data rates that are selectable using a single parameter (any combination of parameters can be added per the constraints discussed in paragraph I.2.3).

The use of the configuration status capabilities is clear in the tables since each function is realized independently. This means that any combination of routing capabilities is selectable since no function affects any other function. It should be noted that there are some restraints from the interfacing equipment (such as recording and playback of the HDRR cannot be done simultaneously by the HDRR) but the HRM will accept and perform the specified functions.

C-4

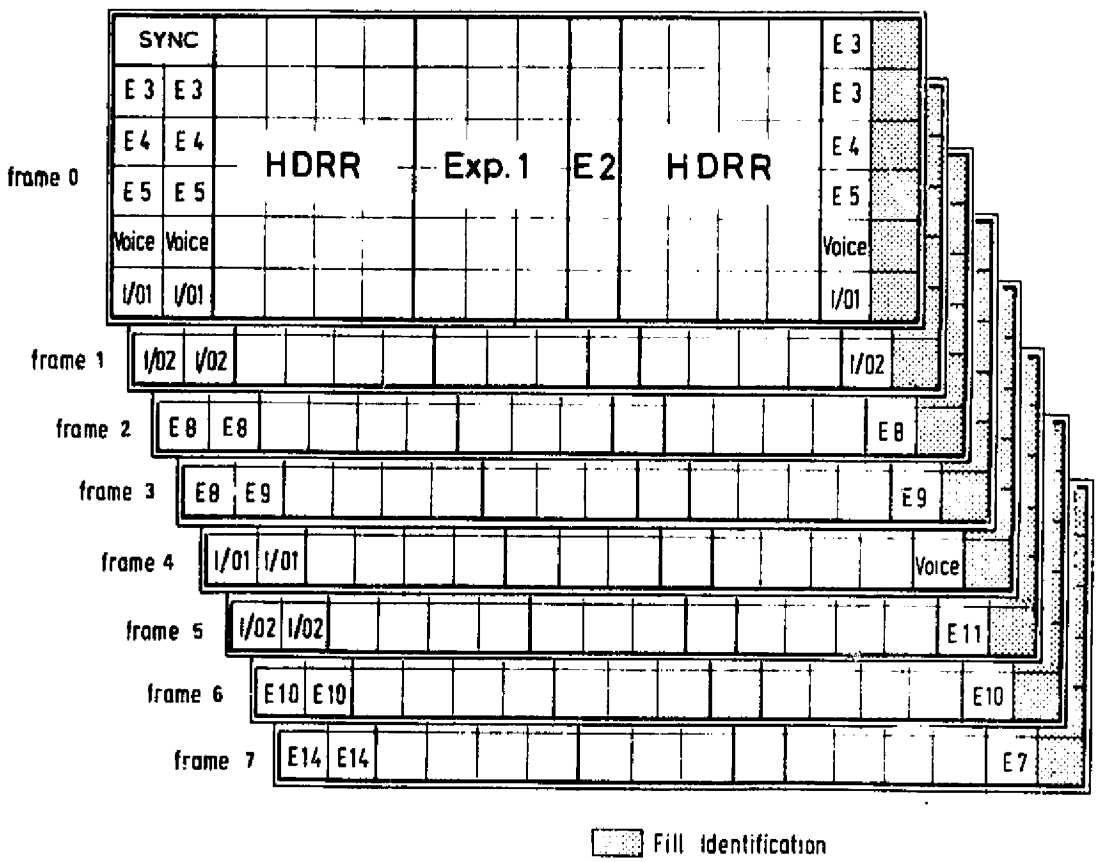


Figure I-4 Example of HRM Format

TABLE I-2

EXAMPLE OF INSTRUCTION TABLE

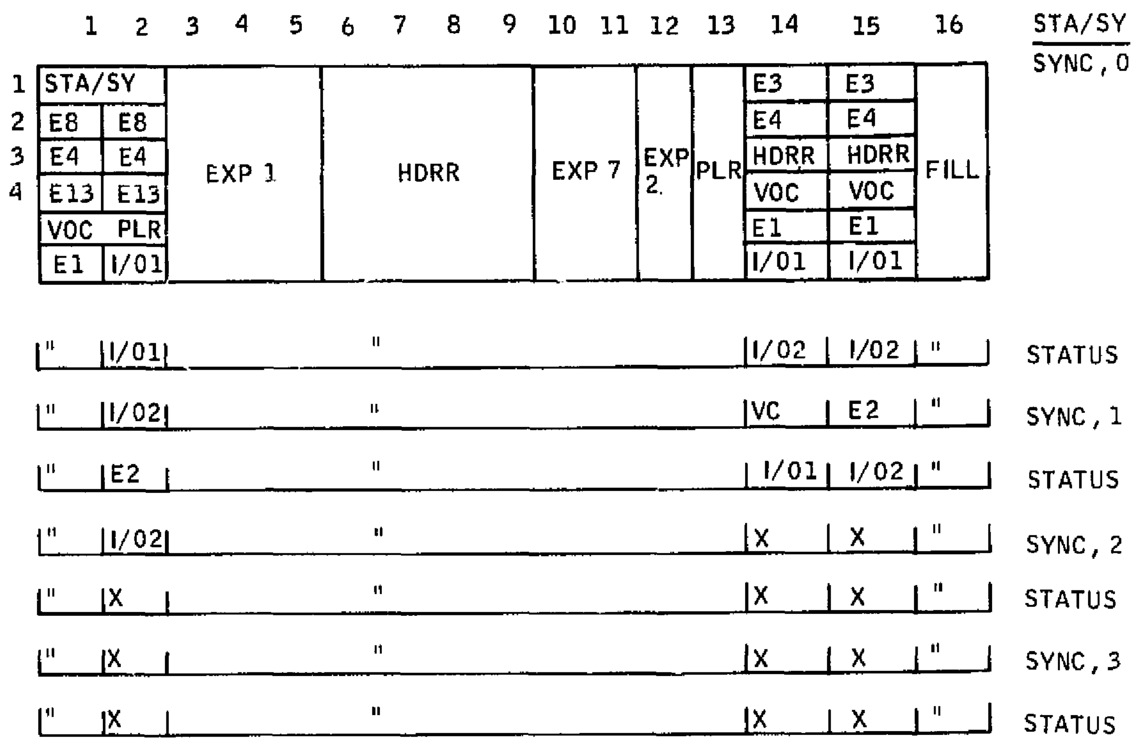
Instruction Word	Mode	Channel	Words	Channel	Words
1	3	HDRR	4	E 1	3
2	3	E 2	1	HDRR	4
3	2	E 3	4	E 4	3
4	2	E 5	3	Voice	3
5	1	I/01	3	I/02	3
6	1	E 8	4	E 9	2
7	1	I/01	2	Voice	1
8	1	I/02	2	E 11	1
9	1	E 10	3	E 14	2
10	1	E 7	1	Skip	0
11	0	Skip	0	Skip	0
12	0	Skip	0	Skip	0
13	0	Skip	0	Skip	0
14	0	Skip	0	Skip	0
15	0	Skip	0	Skip	0
16	0	Skip	0	Skip	0
17	Configuration Status				
18					

TABLE I-3

EXAMPLE OF RATE SHARING

HRM Output Data Rate = 4 Mb/s	
Data Rate Shares	Data Rate Shares
E 1 ≤ 750 kb/s	E 11 ≤ 5.2 kb/s
E 2 ≤ 250 kb/s	E 12 = -
E 3 ≤ 166.6 kb/s	E 13 = -
E 4 ≤ 125 kb/s	E 14 ≤ 10.4 kb/s
E 5 ≤ 125 kb/s	E 15 = -
E 6 = -	E 16 = -
E 7 ≤ 5.2 kb/s	I/O 1 ≤ 26 kb/s
E 8 ≤ 20.8 kb/s	I/O 2 ≤ 26 kb/s
E 9 ≤ 10.4 kb/s	HDRR ≤ 2000 kb/s
E 10 ≤ 15.6 kb/s	PLR = -
	Voice ≤ 130.2 kb/s

(HRM Voice fixed at 128 kb/s)



WORDS 17 AND 18 IN CODEFORM

C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	PIT POS
X	X	X	X	X	X	X	X	X	1	0	0	0	0	0	0	WORD 17
1	1	0	1	0	0	0	0	0	1	1	1	0	0	0	0	WORD 18

KUSP (2 MHz): OFF
KUSP (4 MHz): MUX
KUSP (48 MHz): DACH 1
HDRR : REPRO
PLR : OFF

FREQ (MUX): 4 MHz
FREQ (REPRO): 1 MHz

AA10914(A)-1

Figure I-5 Content of BITE Format

TABLE I-4

EXPERIMENT BANDWIDTHS

PARAMETER	OUTPUT BIT RATE									
	48	32	16	8	4	2	1	0.5	0.25	0.125
WORDS/ LINES	MB/S	MB/S	MB/S	MB/S	MB/S	KB/S	KB/S	KB/S	KB/S	KB/S
4	16	8	4	2	1	500	250	125	62.5	31.25
3	12	6	3	1.5	0.75	375	187.5	93.75	46.88	23.44
2	8	4	2	1	0.5	250	125	62.5	31.25	15.63
1	4	2	1	0.5	0.25	125	62.5	31.25	15.63	7.81
WORDS/ FRAME	MB/S	MB/S	KB/S	KB/S	KB/S	KB/S	KB/S	KB/S	KB/S	KB/S
4	2	1.333	666.7	333.0	166.7	33.33	41.67	20.83	10.42	5.21
3	1.5	1	500	250	125	62.5	31.25	15.63	7.81	2.60
2	1	0.667	333.3	166.7	83.33	41.67	20.83	10.42	5.21	1.30
1	0.5	0.333	166.7	83.33	41.67	20.83	10.42	5.21	2.60	0.65
WORDS/ FORMAT	KB/S	KB/S	KB/S	KB/S	KB/S	KB/S	KB/S	KB/S	B/S	B/S
4	250	166.7	83.33	41.67	20.83	10.42	5.21	2.60	1302	651
3	187.5	125	62.5	31.25	15.03	7.81	3.91	1.95	977	488
2	125	83.33	41.67	20.83	10.42	5.21	2.60	1.30	651	326
1	62.5	41.67	20.83	10.42	5.21	2.60	1.30	0.651	326	163

TABLE I-5

DISCRETE COMMANDS AND MONITORING

COMMAND	TYPE	FUNCTION	VERIFICATION	TYPE
POWER ON	RAAB PULSE	SWITCH HRM ON IN BITE MODE READY FOR COMMANDING	POWER ON/OFF STATUS	RELAY CONTACT ON = CLOSED OFF = OPEN
POWER OFF	RAAB PULSE	SWITCH ALL HRM POWER OFF	POWER ON/OFF STATUS	
BUS CONTROL S/S	BIU RELAY CONTACT	SELECT BIU BUS A OR B (SS) (CONTACT CLOSED = A)	SS BIU MONITOR	RAU, LEVEL 0V = B, +5V = A
BUS CONTROL EXP	BIU RELAY CONTACT	SELECT BIU BUS A OR B (EXP) (CONTACT CLOSED = A)	EXP BIU MONITOR	
			POWER STATUS	LOGIC 1 (+5V) = 0
			SECONDARY VOLTAGE +15V	ANALOG
			SECONDARY VOLTAGE +8V	ANALOG
			SECONDARY VOLTAGE +5V	ANALOG
			SECONDARY VOLTAGE -8V	ANALOG
			TEMPERATURE	ANALOG

TABLE I-6

BIU COMMANDS/MONITORING

BIU COMMAND			VERIFICATION		
OP-CODE (BITS 5-8)	FUNCTION CODE (BITS 10-15)	FUNCTION	LOCATION (HK + OVFL REGISTER) WORD	BIT	LEVEL
		OVERFLOW, EXP 1	1	0	1
		EXP 2		1	
		EXP 3		2	
		EXP 4		3	
		EXP 5		4	
		EXP 6		5	
		EXP 7		6	
		EXP 8		7	
		EXP 9		8	
		EXP 10		9	
		EXP 11		10	
		EXP 12		11	
		EXP 13		12	
		EXP 14		13	
		EXP 15		14	
		EXP 16		15	
		OVERFLOW, VOICE	2	0	1
		PLR		1	
		HDRR		2	
		I/O 1		3	
		I/O 2		4	
		HRE1 RECEIVER ERROR (SS)	3	0	1
		HCS1 C-SYNC (SS)		1	
		HUDC1 UNDEFINED END (SS)		2	
		HME1 MATCH ERROR (SS)		3	
		HRE2 RECEIVER ERROR (EXP)		4	
		HCS2 C-SYNC (EXP)		5	
		HUDC2 UNDEFINED CMD (EXP)		6	
		HME2 MATCH ERROR (EXP)		7	

TABLE I-6 (CONT'D)

BIU COMMAND			VERIFICATION		
OP-CODE	FUNCTION CODE	FUNCTION	LOCATION (HK + OVFL REGISTER) WORD	BIT	LEVEL
0001	001000	VOICE CHANNEL 1 ON	3	8	1
0001	001001	VOICE CHANNEL 2 ON		9	1
0001	001010	VOICE CHANNEL 3 ON		10	1
0001	001100	VOICE CHANNEL 1 OFF		8	0
0001	001101	VOICE CHANNEL 2 OFF		9	0
0001	001110	VOICE CHANNEL 3 OFF		10	0
0001	000001	POWER SAVINGS EXCEPT ROUTING ON (PSO)		11	0
0001	000010	POWER SAVINGS ON, GRP 1 EXP (PS1)		12	0
0001	000011	POWER SAVINGS ON, GRP 2 EXP (PS2)		13	0
-		MUX FUNCTION ON		14	1
0001	000100	EXECUTE NEW FORMAT		15	1
0001	000101	BITE ON	4	0	1
-		BITE GO		1	0
-		BITE ERROR COUNT		2-7 (BINARY TRUE)	XXXXXX
-		FORMAT ID (WORKING)		8-13	XXXXXX
0100	XXXX00	LOAD NEW TABLE (FORMAT + CONFIGURATION)	SEE TABLE I-7		
0100	XXXX11	LOAD DATA INTO FIFO	SEE TABLE I-7		
1001	XXXX00	DUMP TABLE	SEE TABLE I-7		
1001	XXXX11	DUMP HK + OVFL REGISTER	SEE ABOVE		

TABLE I-7

FORMATTING TABLE (CONFIGURATION STATUS) FORMATS

WORDS 1-16

0 1	2 6	7 8	9 13	14 15
MODE	DEVICE ADDRESS (INSTRUCTION N)	WORDS/ DEVICE (INSTR N)	DEVICE ADDRESS (INSTRUCTION N + 1)	WORDS/ DEVICE (INSTR N+1)

BITS 0-1	DEC CODE	MODE
00	0	END OF TABLE
10	1	SUBCOMMUTATION
01	2	NORMAL COMMUTATION
11	3	SUPER-COMMUTATION

BITS 2-6 AND 9-13	DEC CODE	DEVICE ADDRESS INSTRUCTIONS N AND N + 1
00000	0	DUMMY WORD 0
10000	1	EXP NO. 1
01000	2	EXP NO. 2
11000	3	EXP NO. 3
00100	4	EXP NO. 4
10100	5	EXP NO. 5
01100	6	EXP NO. 6
11100	7	EXP NO. 7
00010	8	EXP NO. 8
10010	9	EXP NO. 9
01010	10	EXP NO. 10
11010	11	EXP NO. 11
00110	12	EXP NO. 12
10110	13	EXP NO. 13
01110	14	EXP NO. 14
11110	15	EXP NO. 15
00001	16	EXP NO. 16
11001	19	VOICE CHANNEL
00101	20	PLR
11101	23	HDRR
10101	21	I/O CHANNEL 1 (S/S COMP)
01101	22	I/O CHANNEL 2 (EXP COMP)
11111	31	SKIP

BITS 7-8 AND 14-15	DEC CODE	WORDS/DEVICE INSTRUCTIONS N AND N + 1
11	3	1 WORD
01	2	2 WORDS
10	1	3 WORDS
00	0	4 WORDS

TABLE I-7 (CONT'D)

WORD 17

0–8	9–15	15
SPARES	FORMAT IDENTIFICATION*	PLR ROUTING**

*000000 = BITE FORMAT; 111111 = BITE FORMAT (BB ONLY); ALL OTHER = TBD
**0 = OFF (NO SIGNAL OUTPUT): 1 = MUX

WORD 18

0–3	4–6	7–9	10–11	12–13	14–15
HRM FREQUENCY (MHZ)	HDRR REPRO FREQUENCY (MHZ)	KUSP 48 MHZ ROUTING	KUSP 4 MHZ ROUTING	KUSP 2 MHZ ROUTING	HDRR ROUTING

BITS 0-3	DEC CODE	HRM FREQUENCY
0000	0	0.125
1000	1	0.250
0100	2	0.500
1100	3	1.000
0010	4	0.125
1010	5	0.250
0110	6	0.500
1110	7	1.000
0001	8	0.125
1001	9	1.0
0101	10	2.0
1101	11	4.0
0011	12	8.0
1011	13	16.0
0111	14	32.0
1111	15	48.0

TABLE I-7 (CONT'D)

WORD 18 (CONT'D)

BITS 4-6	DEC CODE	HDRR REPRO FREQ
000	0	TEST INPUT
100	1	2.0
010	2	4.0
110	3	8.0
001	4	12.0
101	5	10.0
011	6	24.0
111	7	32.0

BITS 7-9	DEC CODE	KUSP 48 MHz ROUTING
000	0	OFF
100	1	OFF
010	2	OFF
110	3	OFF
001	4	DACH NO. 1
101	5	DACH NO. 2
011	6	HDRR DIRECT DUMP
111	7	MUX

BITS 10-11	DEC CODE	KUSP (4 MHz) ROUTING
00	0	OFF
10	1	PLR DIRECT DUMP
01	2	HDRR DIRECT DUMP
11	3	MUX

BITS 12-13	DEC CODE	KUSP (2 MHz) ROUTING
00	0	OFF
10	1	PLR DIRECT DUMP
01	2	HDRR DIRECT DUMP
11	3	MUX

BITS 14-15	DEC CODE	HDRR ROUTING
00	0	REPRO (DATA OFF)
10	1	DACH NO. 1
01	2	DACH NO. 2
11	3	MUX

I.2.4.2 System Description and Restraints

A. Commands. The receipt of formatting commands must be verified before an execute command is given since no automatic functions are provided to avoid execution of false commands. The HRM will attempt to execute all commands, but no damage can occur as a result.

No provision is made for negating a power savings command since damage would result if this were possible. The HRM must be turned OFF to discharge the filter capacitors to resume normal operation (full power) again.

The BITE mode is entered when power is turned ON or if the BITE ON command is given. The BITE is turned off automatically if an execute NEW FORMAT command is given.

B. Formatting. Martin Marrietta Corporation (MMC) has supplied the following formula, which defines the limitations for format allocations with respect to HRDM overflow/empty if the conditions on user frequency and output register setup described above (i.e., the user rate ±1 percent and the output rate is selected within ±0.5 percent of the user nominal rate).

$$C = 16 + (WX \frac{A}{B})$$

Where:

A = Output channel bit rate (selected)

B = Total HRDM input bit rate

C = Number of words to selected channel during W

W = Number of words in the input data stream
This definition must be true for all values of W.
(NOTE: This defines the format word allocation to prevent overflow of the output channel FIFO's)

The formula indicates that at least 17 consecutive (or closely spaced) words for C are required before the formula can be violated and that the smallest W for any given C is worst case. The largest W that need be considered is longest cycle period which is 16 words for mode 3, 96 words for mode 2, and 768 words for mode 1. Therefore:

- Mode 3 (words/line) cannot violate the formula

- Mode 2 (words/frame) can violate the formula if 21 consecutive words are assigned to one channel using Mode 2
- Mode 1 (words/format) can violate the formula if 17 consecutive words are assigned to one channel using Mode 1.

Although it is possible to generate a format which violates these conditions, it would represent extremely inefficient use of the formatting capabilities.

If the HRDM is programmed for burst mode, then no violation can occur if the output bit rate is greater than the user bit rate. However, it is possible to operate the HRM in burst mode and the HRDM in continuous mode. In this case, the formula still applies but "C" must be selected according to the words used out of the allotment in the format. Some care should be taken by the user because violation would be possible. For example, if a user is assigned four words in Mode 3, but uses only 24 consecutive words per format, a violation would occur.

A = 24

B = 768 (words/format)

C = 24

W = 96 (words during which 24 input words occur)

24 is not $\leq$ 19 (violation)

I.2.4.3 Setup and Operation. The complete setup and control philosophy for the on-orbit HRM via the MCC is undefined at this time. The following description of HRM setup and operation in a test-bed configuration provides for information relative to the setup considerations. This section describes the[1] general steps that must be followed in order to begin operation of the units involved. The details of each step are a mission planning function and cannot be presented here. The first step is self-test of each unit which can be initiated as follows:

A. HRDM Unit Tester (UT) Self-Test. Pushbutton operation, fully automatic will stop on completion.

B. HRDM Self-Test. Pushbutton initiate, fully automatic with stop on completion. HRDM self-test can be executed by the HRDM or the HRDM UT in which case the interfaces are included in the self-test loop.

C. Input Simulator Self-Test. Initiated by 2 setups of the address and data words, fully automatic, and stops on failure or completion. Run time is between a few seconds and minutes depending on operator choice of bit rate. NOTE: The HRDM and HRDM UT execute complete test and stores failures for readout during test. The HRM UT stops on failure but continues test if the execute button is depressed.

D. HRM Power On. HRM enters BITE and can indicate GO/NO GO after 8 seconds; 0.5 percent of the format contents are tested for corrections. In addition, the number of errors detected are added to a 6-bit rollover binary counter. The BITE mode is stopped if a new format is executed but can be reentered by telecommand. Assuming successful completion of the BITE mode, the next step is to enter formats in the associated units. If the bench test configuration is used, the entire operation is executed via the HRM UT computer keyboard. (It should be mentioned that diagnostics are available for the computer and a diagnostic can be performed via computer on the BIU simulator in the HRM UT).

E Load HRM Format. Eighteen words of 16 bits are loaded via BIU interface. Readout is commanded and compared with the input for verification.

F. Load HRDM Format. The HRM UT can convert the 18 words of the HRM format to the 768 words required to define the HRDM format. In addition, the sync pattern is selected and the clock registers are loaded to determine mode and frequency of the output channels. Finally, the FM ID cross-reference table will be loaded if the format number and ID are different.

G. Input Simulator Setup. Each channel of the input simulator is programmed for mode and rate (must be the same as the HRDM clock register) and additional functions are selected as necessary (DACH, GMT, Voice).

H. The channel to be tested is selected for output on the reference channel interface of the Input Simulator.

I. Execution of the format is commanded for the HRM which will begin the new format synchronous after the next complete format (one cycle of the old format is required while the execution flag is transmitted).

J. The HRDM will detect the flag and prepare for the new format. Upon receipt of frame zero, the HRDM will automatically enter the new format parameters and output register data.

K. The HRDM UT is now commanded to perform a BER test on a specified channel which causes reset of the BER comparater and counter. The resulting BER is read out on command after 16 megabits have been checked. Read-out can be repeated as often as desired.

The above procedure can be repeated in part or whole. Normally, successive channels would be tested by selecting a new reference channel in the HRM UT and commanding a new channel in the HRDM UT for each channel in a format before a complete setup is repeated.

I.3 HRDM

I.3.1 HRDM Description. The HRDM will receive, via the Ku-band link, the multiplexed Spacelab experiment digital data and clock from 16 or fewer experimenters. It will demultiplex the data and distribute it to output channels corresponding to the HRM input channels. Various support data such as voice annotation, a GMT time base, payload recorder data, HDRR data, and two I/O channels will also be demultiplexed to output channels for the experimenters and others use.

Auxiliary test data and clock inputs will be available for running operational tests with the UT tester to evaluate system quality prior to mission use.

A bit error indicator is provided to continuously verify the quality of the HRDM downlink input by displaying bit error rate.

The HRDM format generator contains 16 programmable read-only memory (PROM) stored programs (including BITE) that will be installed prior to a mission according to the formats planned to be generated in the HRM. It also has a memory capacity for two formats that can be programmed and selected by the ground computer.

The HRDM is composed of the following subsystems (figure I-6):

- Input cirucit
- Sync detector
- Format generator
- BCH decoder and data buffer
- Output channels
- Voice channels
- Microcontroller
- Self-test
- Bit error indicator.

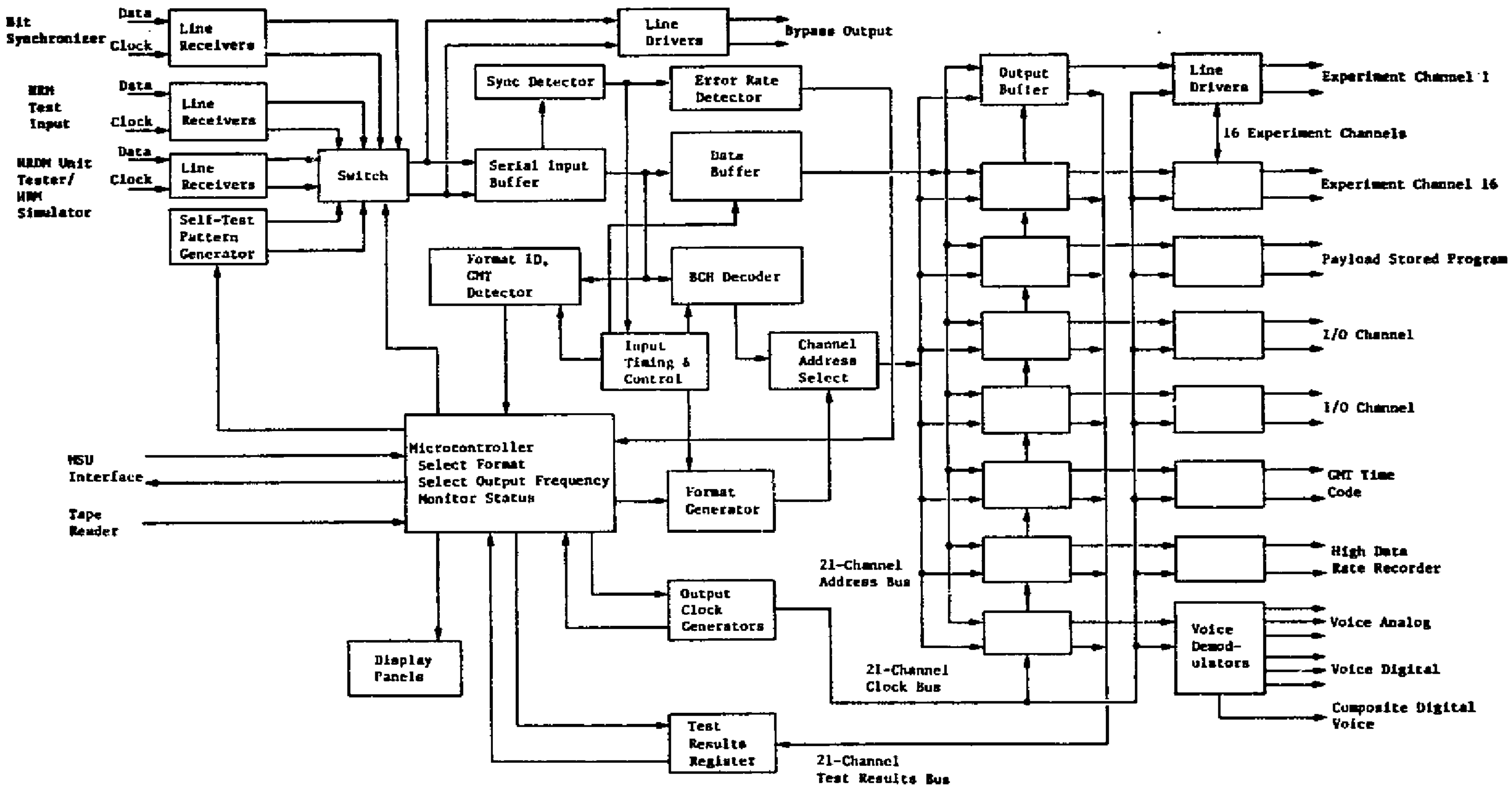


Figure I-6 High Rate Demultiplexer System Block Diagram

I.3.1.1 Input Configuration. In normal operation the HRDM will receive serial input data and clock. In test configurations, data will be received either directly from an HRM or the HRDM UT. The operational or test modes can be selected manually by a front panel switch on the HRDM. The choice of the HRM or the unit tester as a test data source will be made by front panel switch selection. The HRDM can accept data or data complemented through selection of a front panel switch.

I.3.1.2 HRDM Sync Detector. The HRDM must frame synchronize itself with the data stream coming from an earth station or the HRDM UT/before data can be decommutated.

Incoming data are clocked into the 32-bit serial register. The 28-bit optimum code in the sync word enters the registers followed by the 4-bit frame count. Initially the sync circuitry can be considered in a search mode looking for the 28-bit code. Figure I-7 is a flow chart of the synchronization sequence. When the correct code is recognized with no more than 1 bit in error, the bit and word counters will be zeroed and the frame count contained in the data stream will be loaded in the frame counter. The HRDM will be considered in a probational state during the next frame until the sync word time slot is reached. If sync is recognized and the frame counter compares with the received frame count during the proper frame count and at the proper bit count ±1 bit, the demultiplexer will be considered in lock and 16 bits of data will be transferred to the data buffer.

Once frame sync is established ($\leq$ 3 frames), the time to change format address and clock data with a data rate change is $\leq$ 3 more frames. The time to synchronize the format counter may take up to four more frames but in any case synchronization to a new format will be accomplished in $\leq$ 10 frames. If a format change is made without a rate or sync word change, resynchronization will only involve changing address and clock data, which can be accomplished in $\leq$ 3 frames.

After lock is acquired, the content of the internal frame counter will be compared with the incoming data stream at the time a sync word and frame count should have occurred. If the frame counter compares correctly, the system will be assumed to be in lock. If there is a frame count error, a frame error counter will increment once. When the time comes to look at the data for a sync word, the frame counts will be compared and the 28 bits of the sync code will also be looked at. If the frame count doesn't compare, the error counter will be incremented one more count. However, if the sync code is correct (no more than 1 bit in error), the frame count of the data stream will be loaded into the frame counter. If the frame count is compared correctly at the next sync word time, the frame count error counter will be cleared. If the frame count is wrong again, the HRDM unit will revert to search.

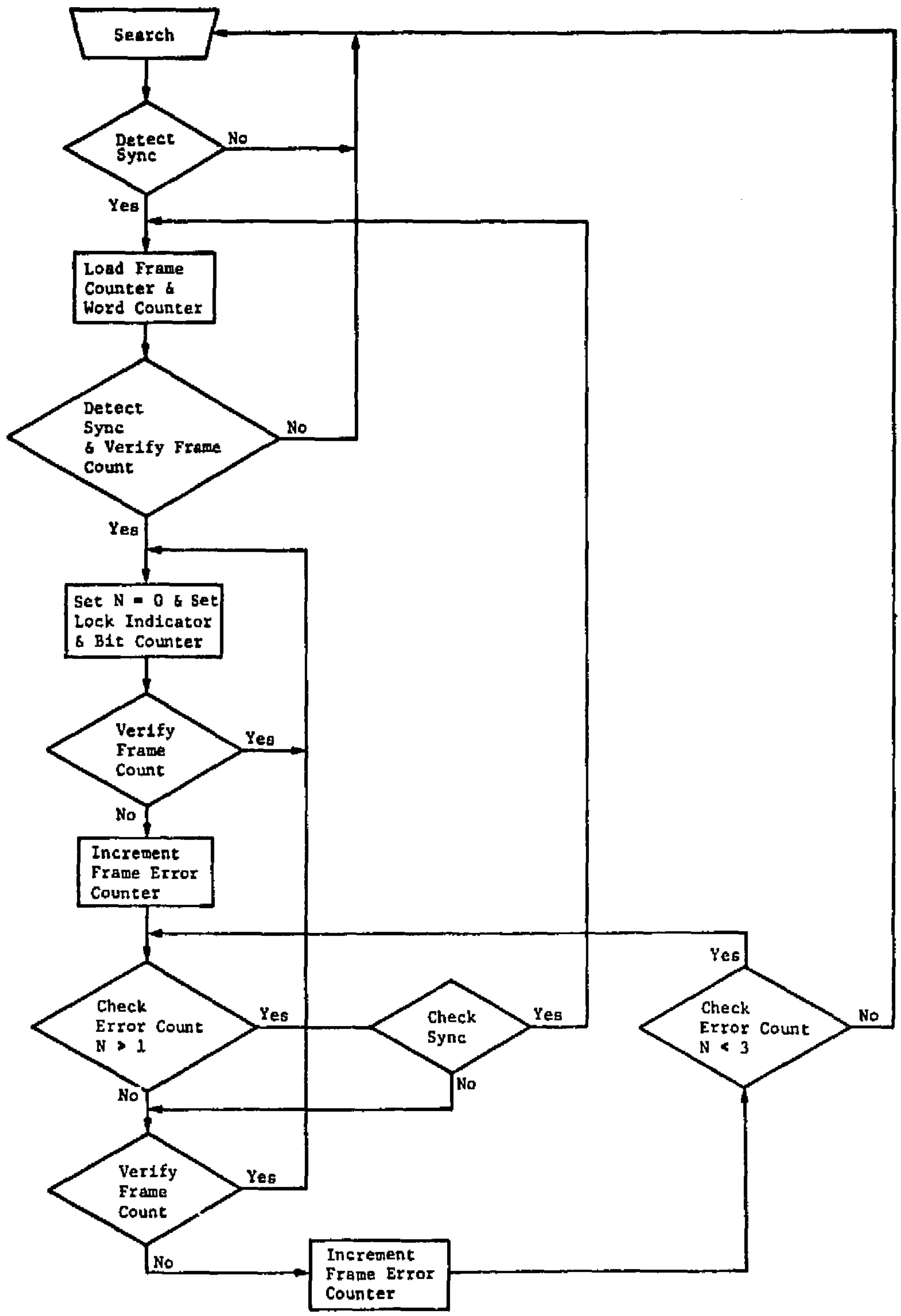


Figure I-7 Synchronization-Search/Lock Flow Chart

I.3.1.3 Format Generator. The format generator will store up to 16 user formats in programmable read-only memories, plus two formats in read/write (R/W) memories. Each user format consists of 8 frames of 96 words (768 5-bit words). Each word represents the channel address of the corresponding word in the format. By definition, one engineering format consists of 16 frames of 192 words so the format generator is cycled through four times every engineering format.

Figure I-8 shows a block diagram of the format generator. The format ID latch is loaded with the 6-bit format ID from the microcontroller. The 6-bit ID is decoded to select the section of memory (either PROM or R/W memory) that stores that format.

The word counter is synchronized with the counter from the sync detector. The contents of the counter, which resets after 768 counts, are the addresses of the format memory.

The contents of the selected memory location are transmitted to the BCH decoder and data buffer where they are decoded and used to select the appropriate output channel. The PROM's will be preprogrammable before a mission but the read/write memory will be loaded by the microcontroller under local manual or ground computer control. The microcontroller selects the load counter output as the address to the read/write memory via a multiplexer. The microcontroller loads a starting address into the load counter, transmits a 5-bit data word to the memory, and increments the load counter. This sequence is repeated until the format is loaded (768 words).

If the incoming format contains data entirely from the HDRR, which are in reverse order, it will be necessary to detect the sync word in reverse order. The HRDM will be preprogrammed to accept reverse data so the forward/reverse mode select will be programmed to reverse and data will shift into the opposite end of the input shift register so the sync word will appear "forward." The frame count will be programmed to count down because reversed data will have frames counting down.

Figure I-9 shows a flow diagram of the automatic format change .

Circuitry located in the format generator continually monitors the format change flag in the status word. Whenever the change flag is a logic 1, the format ID bits are loaded into a register. During each successive frame, the format ID bits are compared to those stored from the preceding frame until they agree for three consecutive frames. It then sends an interrupt to the processor. The processor reads the format ID number, and prepares to load new values into all output channel clock registers.

Upon detecting frame 0, word 0, format generator circuit switches to the new format and sends another interrupt to the processor. The processor loads all output channel clock registers.

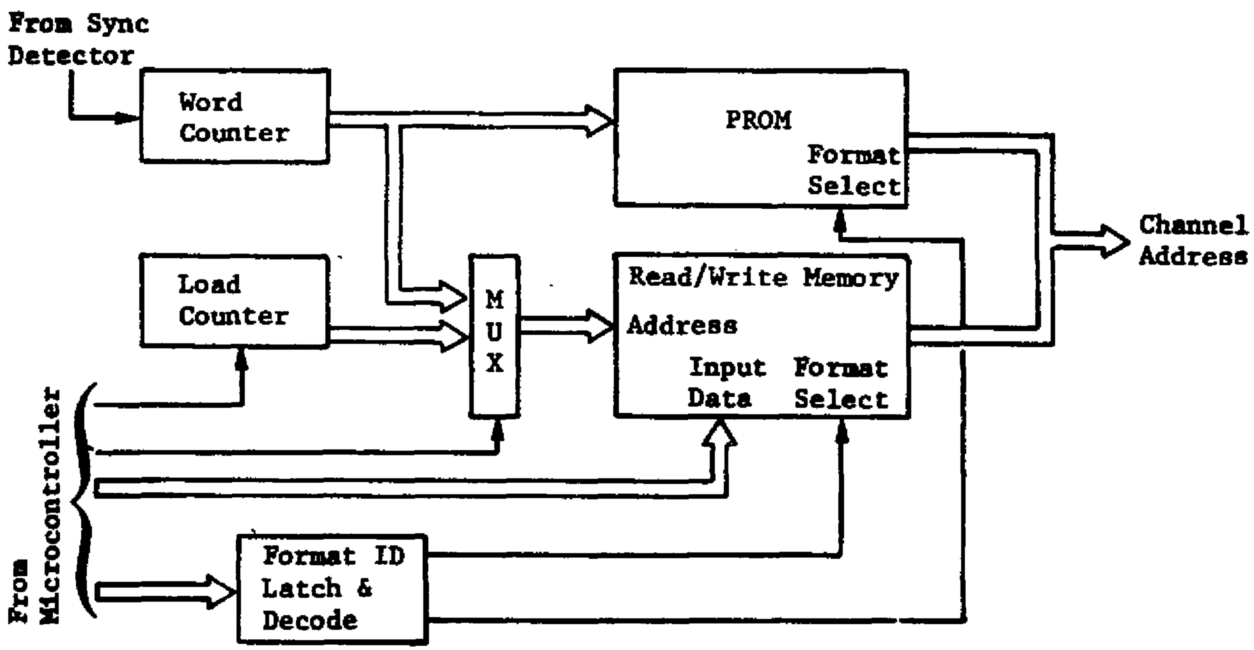


Figure I-8 Format Generator Block Diagram

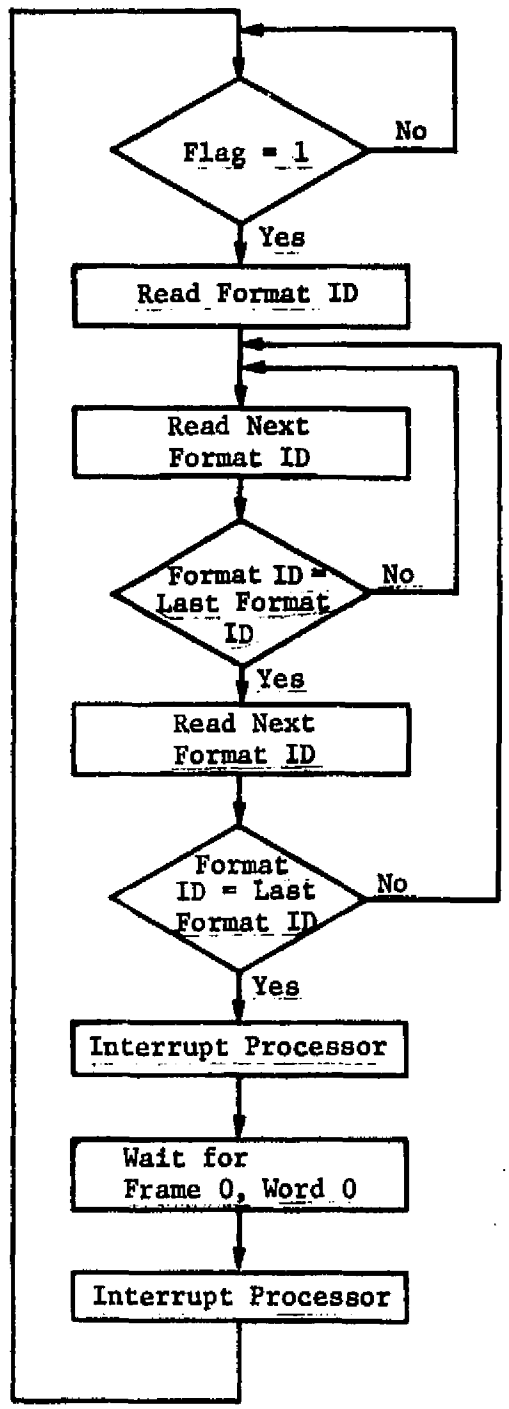


Figure I-9 Automatic Change Flow Diagram

I.3.1.4 Experiment Channel Configuration. Figure I-10 is a block diagram of an experiment data output channel. Each 16-bit data word from the serial data buffer is transferred as two 8-bit bytes into an 8-bit × 128-word FIFO memory.

Data is clocked into the FIFO memory at the serial word rate for that channel and data is clocked out of the memory by a synthesized clock. If the input data is continuous, the synthesized clock is programmed to a frequency corresponding to the rate of the data as it was generated. The synthesized clock is regulated by comparing the data rate of data-in to data-out so there is a smooth flow of output data without a data loss or gaps. The controls for data output can also be preprogrammed to transmit data in predetermined bursts.

Each output channel has a 64-word buffer that is nominally half full in the continuous data mode. An up/down counter tracks the number of words in the buffer by counting up when a word is added, and down when a word is taken away. The count on the output of the up/down counter is used to determine whether the output frequency needs to be increased or decreased.

Clock regulation is accomplished by varying the value of the reference divider N. When a greater output frequency is desired, N is decremented from nominal by one. When a lower output frequency is desired, N is incremented by one. A PROM is used to determine at what thresholds of the up/down counter N will be changed from its nominal value. The output of the PROM is a zero, one, or two, and is always added to the value N-1. The result is used as the reference divider in controlling the output channel VCO.

Table I-8 is a recommended table of divider ratios suitable for containing an approximate monotonic set of frequencies at about 0.1 MHz intervals. The binary programmable divider D ($\div 2^0$ to 2^{16}) scales the outputs of the VCO's to get the output clocks. Output clock rates can be programmed in 1 percent relative intervals from 200 Hz to 10 MHz by using table I-8 and the possible values of D.

I.3.1.5 Experiment Data Output in Burst Mode. When the experimenter output channels are programmed to operate in the burst mode, the clock regulator circuit will be disabled. In this mode the data is read from the FIFO as soon as it propagates to the FIFO output. Table I-8 and the divider D are used for setting the output clock rate of the burst data, but the burst rate is determined by the program rate at which data is received in the serial bit stream.

I.3.1.6 HDRR Output Channel Configuration. The configuration of the HDRR output channel is the same as the experiment channels except there is no burst mode. The HDRR output clock generator is basically the same as the experiment clock generators except that the reference frequency is 30 MHz, the output divider D is programmable only from 2^0 to 2^4, the frequency values of table I-8 must be multiplied by 2, and the HDRR channel does not operate in the burst mode. The VCO frequency range is approximately 18 to 40 MHz, which, when used with combinations of D, is more than adequate for all HDRR bit rates between 2 and 32 Mb/s.

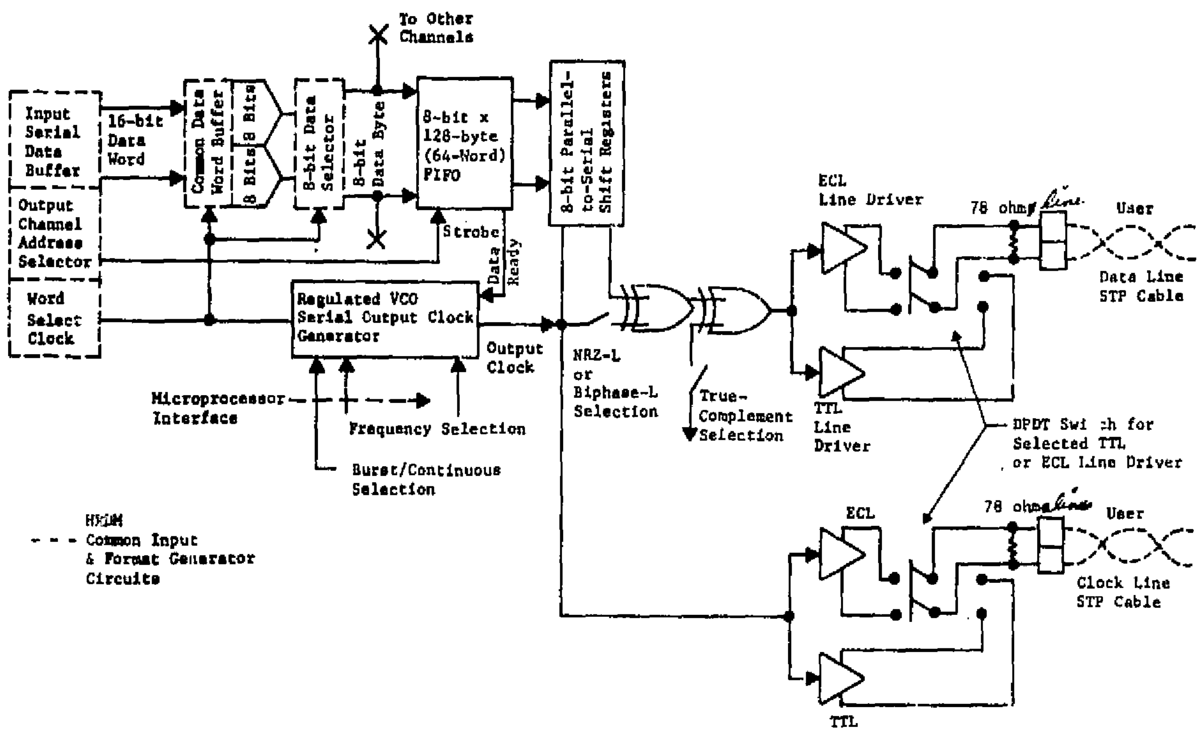


Figure I-10 HRDM Experiment Data Output Channel Simplified Block Diagram

TABLE I-8
HRDM EXPERIMENT CHANNEL OUTPUT VCO FREQUENCIES AS A FUNCTION OF
REFERENCE DIVIDER N AND FEEDBACK DIVIDER M

f_{VCO}, MHz	M	N	f_{VCO}, MHz	M	N	f_{VCO}, MHz	M	N	f_{VCO}, MHz	M	N
20.0	64	48	16.9	62	55	13.8	46	50	10.7	45	63
19.9	65	49	16.8	56	50	13.7	53	58	10.6	41	58
19.8	62	47	16.7	59	53	13.6	49	54	10.5	42	60
19.7	63	48	16.6	62	56	13.5	54	60	10.4	43	62
19.6	64	49	16.5	55	50	13.4	50	56	10.3	44	64
19.5	65	50	16.4	59	54	13.3	55	62	10.2	34	50
19.4	62	48	16.3	63	58	13.2	44	50	10.1	43	64
19.3	58	45	16.2	54	50	13.1	55	63	10.0	42	63
19.2	64	50	16.1	59	55	13.0	52	60	9.9	35	53
19.1	65	51	16.0	64	60	12.9	55	64	9.8	32	49
19.0	57	45	15.9	53	50	12.8	53	62	9.7	33	51
18.9	63	50	15.8	58	55	12.7	50	59	9.6	32	50
18.8	57	47	15.7	45	43	12.6	42	50	9.5	38	60
18.7	61	49	15.6	52	50	12.5	50	60	9.4	37	59
18.6	62	50	15.5	63	61	12.4	43	52	9.3	31	50
18.5	65	51	15.4	41	40	12.3	50	61	9.2	38	62
18.4	65	53	15.3	52	51	12.2	48	59	9.1	37	61
18.3	61	50	15.2	64	63	12.1	46	57	9.0	39	65
18.2	62	51	15.1	64	63	12.0	48	60			
18.1	64	53	15.0	64	64	11.9	46	58			
18.0	60	50	14.9	58	61	11.8	48	61			
17.9	62	52	14.8	64	65	11.7	46	59			
17.8	57	48	14.7	50	51	11.6	48	62			
17.7	59	50	14.6	37	38	11.5	46	60			
17.6	61	52	14.5	59	61	11.4	38	50			
17.5	63	55	14.4	48	50	11.3	46	21			
17.4	58	50	14.3	61	64	11.2	47	63			
17.3	60	52	14.2	54	57	11.1	37	50			
17.2	62	54	14.1	47	50	11.0	44	60			
17.1	65	57	14.0	56	60	10.9	40	55			
17.0	60	53	13.9	51	55	10.8	36	50			

Note: $f_{VOC} = \frac{M}{N} \times 15$ MHz where nearest N and M are the programmable frequency divisions of f_{REF} and f_{VCO} that are compared by the phase detector in the VCO control loop.

I.3.1.7 Payload Recorder Output Channel Characteristics. The payload recorder output channel characteristics are identical to those of an experiment channel (for design standardization) although the channel will be operated only at 1 Mb/s and not in the burst mode.

I.3.1.8 I/O Channel Characteristics. The I/O channel characteristics are identical to the experiment channel characteristics.

I.3.1.9 GMT and Status Word Decommutation Description. The HRDM must extract the status word from the incoming bit stream. The status word will contain various bits of information including the format ID, format change flag, HDRR routing, HDRR frequency, HRM output bit rate, GMT and flight number. The HRDM format generator flags the 96th and 97th words in each frame as the status word. They will be loaded in a register and will be available for reading by the microcontroller. They will also be displayed on the front panel in various forms. The flight number and GMT will be displayed in decimal form on the seven-segment displays. The other information will be displayed on 24 individual LED's identified as format configuration status bits 0 through 23.

The GMT information will be loaded into a shift register from the input data buffer/sync detector register and then shifted out in bursts of 56 bits each. The bit rate is the HRDM input bit rate divided by 512, with a burst occurring every format. The 56 bits will contain 8 bits each for hundredths of seconds, seconds, minutes, hours, days, hundreds of days (four bits) and year (four bits), and flight number. The most significant bit (bit zero) of the flight number is transmitted first.

The output data and clock is always provided in NRZ-L form at TTL levels. The line drivers are identical to those already described for the experiments. There is also an interface from the status register to the microcontroller input bus so data can be read to the external computer.

I.3.1.10 Voice Channels. The three-channel composite digital voice signal will be demultiplexed by an experiment-type output channel. This 128-kb/s data and clock are outputs of the HRDM. Each 16-bit data word of the composite data stream consists of four bits of data and a status bit for each of the three voice channels, and there is a spare bit. The composite data and clock are available as TTL-compatible outputs from the HRDM. The composite digital data is further decommutated to provide the three digital data streams and their clocks as TTL-compatible user outputs.

I.3.1.11 HRDM Total Data Output Configuration. Except for the analog data voice characteristics, all data from the various HRDM output channels will be available to the user in a variety of forms, some of which have been discussed. In summary the variety of characteristics are:

- Burst or continuous

- TTL- or ECL-compatible signal levels
- NRZ-L all channels, or biphase-L below four Mb/s
- Data or not data.

The choice of burst or continuous data is part of the format program. The choice of the other characteristics will be made manually by switches mounted inside the HRDM.

Since all configurations are not applicable to all channels, table I-9 presents a user matrix. In no case will a clock be presented in the absence of data.

I.3.1.12 Self-Test. On receipt of a command from the ground station computer or the front panel, or on power turn-on, the HRDM will perform a self-test routine. This routine will be sufficient to verify proper operation of the sync detector, BCH decoder, status word buffer, channel address logic, format generator, output buffers output clock generators, and the microcontroller. Self-test is used during normal operation to verify that the HRDM is generally functional except for the interface cirucuits. This test will be effective to detect most system failures. Input to output data quality and diagnostic tests can only be performed with the unit tester. When all tests have been completed, the controller lights the appropriate indicators on the front panel to indicate that all tests were passed, or to indicate which test(s) failed. Figure I-11 shows a flow diagram of the self-test routines.

I.3.2 HRDM Operating Modes. The HRDM modes of operation will depend on the selected format. If the format contains all real-time data, this data will be demultiplexed to the appropriate output channels for direct use of the experimenter. The total serial data will also be available from the HRDM bypass data output. This data is available to the ground station for recording or other purposes.

If the serial bit stream contains real-time data and HDRR data, the HDRR data will be available at the HDRR output for recording or other uses. If the data is recorded, the tape can be played at a later time in the reverse direction (which would be forward as generated), and played back into a serial input of the HRDM for demultiplexing to the user.

When the serial bit stream contains only an HDRR dump of the composite HRM output, the selected format will set up the HRDM for reverse data and the HRDM will sync on the reverse sync word. The data can then be decommutated to the users, but in reverse order.

Another mode of operation is with the HRM BITE format. The corresponding format will be selected in the HRDM, and the BITE data can be demultiplexed to the user channels and status words provided to the ground computer. A front panel switch on the HRDM also provides for manually disabling the demultiplexing of BITE data.

TABLE I-9

USER MATRIX

Channel	Mode 1	2	3	4	5	6	7
Experiment	X	X	X	X	X	X	
HDRR			X	X	X	X	
Payload Recorder			X		X		
I/O							X
GMT	X						
HRM Bypass				X			
Digital Voice			X				

where:

Mode 1 is NRZ-L burst TTL
Mode 2 is NRZ-L burst ECL
Mode 3 is NRZ-L continuous TTL
Mode 4 is NRZ-L continuous ECL
Mode 5 is Biphase-L continuous TTL
Mode 6 is Biphase-L continuous ECL
Mode 7 is Biphase-L burst TTL

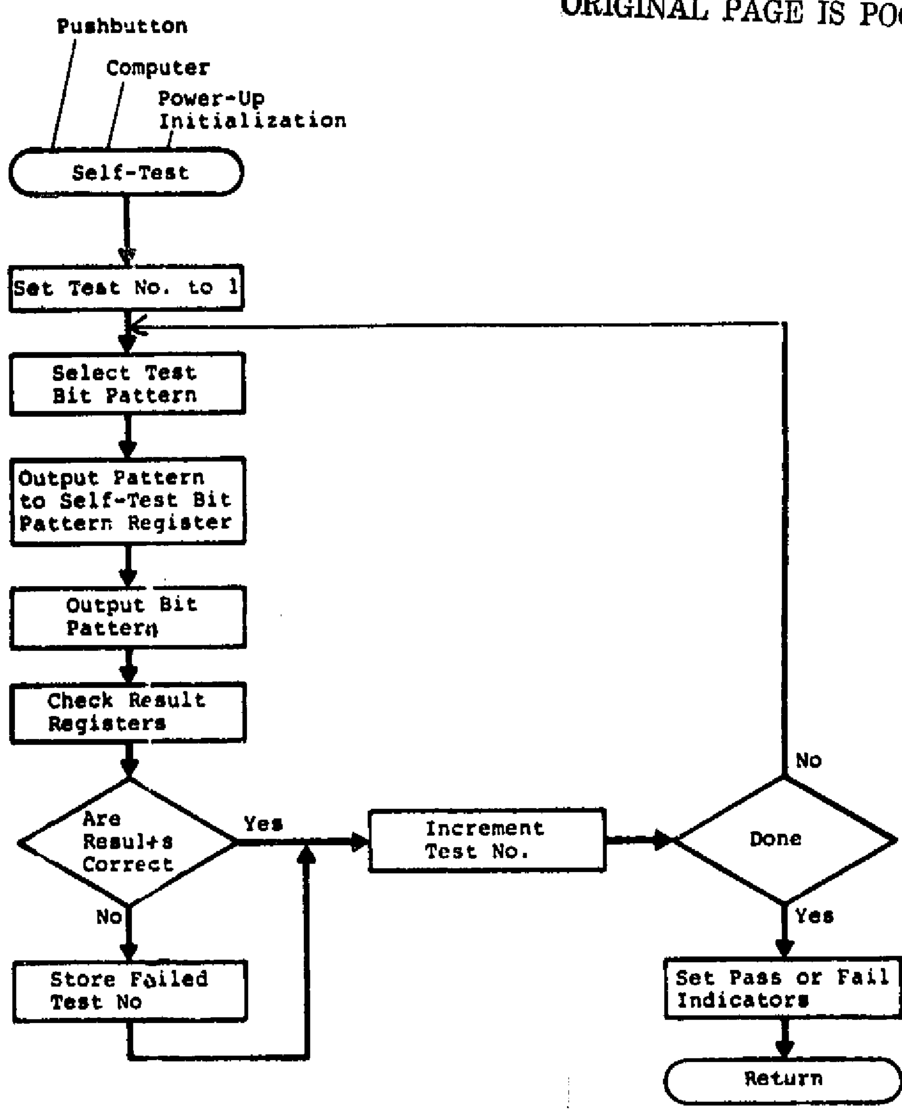


Figure I-11 Self Test Routine Flow Diagram

In addition to the normal operational modes, there will be several test modes. One is the HRDM self-test mode enabled by power up, or selected either by a front panel switch or remotely by the ground computer. Another test mode that can be used during operations is to connect a selected HRDM output channel to the HRDM unit tester. A reference data pattern can then be selected in the UT corresponding to a test pattern generated at the experiment input to the HRM. The UT then can sync to the pattern out of the HRDM and run a bit error test to check data quality. This configuration is possible for any selected channel, including the HDRR. In the case of the HDRR, a repetitive test pattern will be first recorded and a corresponding test pattern generated in reverse by the UT for reference to run a bit error check.

I.3.3 HRDM Format Structure. The HRDM operation is oriented to the 16-frame engineering format with each frame containing 192 words. Figure I-12 illustrates the relationship of the engineering format to the 8-frame user format around which the HRM formatting is structured. The key points of the overall structure are as follows:

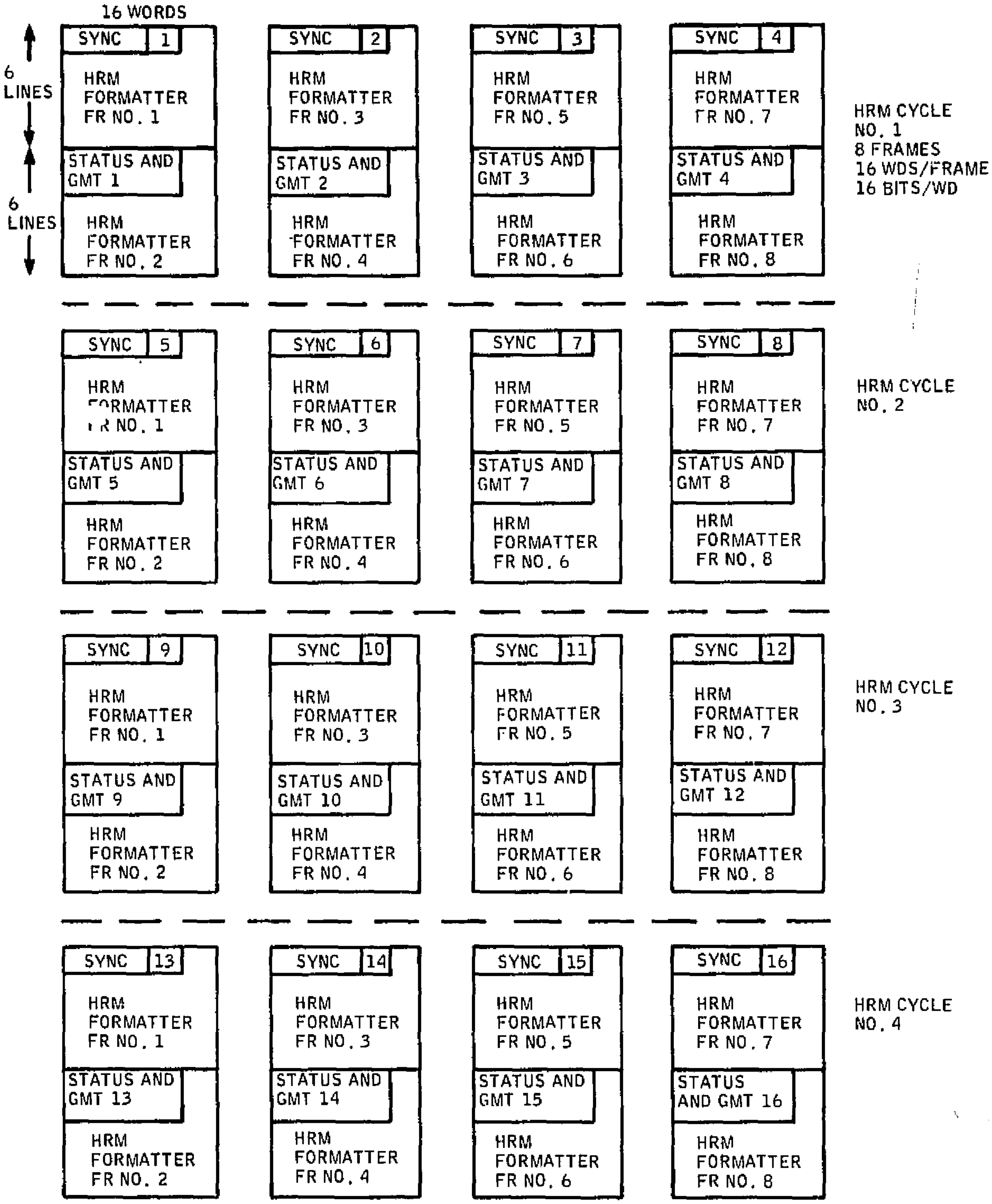
A. The HRM formatter operates on an 8-frame, 96-word/frame basis; therefore, the basic HRM format is repeated four times within the engineering format.

B. Although the HRM formatter is oriented to 8 frames, there is a frame counter in the HRM which counts frames 0-15 (4-bit counter). This count identifies the engineering frame and is included as part of the pattern for synchronizing the HRDM.

C. The frame count is also used to identify the data contained in the GMT portion of the status words. The GMT is subcommutated across 16 engineering frames, 8 bits at a time.

I.3.3.1 HRDM Format Tables. The HRDM can be operated using preprogrammed formats resident in PROM's, or a format can be loaded into RAM via the MSU interface. The basic demultiplexing scheme of the HRDM is to use the word counter address to interrogate a table which contains 768 words. These words specify a device number for each one of the 768 words in the engineering format. The device number is the HRDM nomenclature for output channels. These numbers correspond to HRM experiment and recorder inputs as indicated in table I-10.

I.3.3.2 Format Table Loading. The communication protocol used in loading the HRDM RAM format tables is described in paragraph I.3.4. The format tables are loaded in blocks of 32 words. Two additional words specify the RAM to be loaded and the starting address within the RAM. The format loading words are defined in table I-10.



NOTE: SINCE HRM CYCLE IS REPEATED 4 TIMES, THE HRDM FORMAT TABLES CONSIST OF 768 ENTRIES (8 HRM FRAMES X 96 WORDS)

AA10912(B)-3

Figure I-12 HRDM FORMAT (16 FRAMES, 192 WORDS/FRAME, 16 BITS/WORD)

TABLE I-10

HRDM FORMAT LOADING

- Word 1: 1001 0010 00XX RAM select (01 = RAM 1; 10 = RAM 2)
- Word 2: DDDD DDDD DDDD Address of first word (BCD: 0-734)
- Word 3-4: 1000 XXOD DDDD Device number (XX per word 1)
- The loading addresses are incremented from the starting address given in word 2
- The first 6 bits of words 3-34 are 0000 for readout
- The device numbers used by the HRM are given in this appendix and are to be used also by the HRDM (bit positions are reversed)
- 768 total device numbers are required for format definition. Device numbers for sync, configuration status and full ID are as follows:

CONTENT	BINARY	DECIMAL
DUMMY	00000	0
EXP 1	00001	1
EXP 16	10000	16
VOICE	10001	17
PLR	10010	18
HDRR	10011	19
I/O 1	10100	20
I/O 2	10101	21
SYNC 1	11001	25
SYNC 2	11010	26
STATUS 1	11011	27
STATUS 2	11100	28
BCH	11101	29

I.3.3.3 Clock Register Loading. The serial output rate for each HRDM channel (device number) has to be specified in addition to loading the Format Table. The output clock rates are specified for three channels at a time in a block of nine words. The word formats are specified in table I-11.

I.3.3.4 Format Example. Table I-12 illustrates the relationship of the HRDM format table loading to the basic HRM user format. The example selected is user frames 0 and 1 of the HRM formatting example given in paragraph I.2.3.2. This permits further direct comparison of the HRM and HRDM format specification. The two user frames are contained in the first engineering frame of the HRDM engineering format. Table I-13 illustrates the HRDM format loading messages required to demultiplex the first engineering format frame. Similar messages are required for the other 15 frames. The table just illustrates the device numbers and functional effect of the two preamble words instead of the hexadecimal codes described in table I-10.

I.3.4 HRDM Control and Monitoring[3]. The HRDM shall be controlled and monitored either from a local manual control panel or from an MSU.

I.3.4.1 Manual Control/Monitoring. The HRDM shall provide for manual and remote control capabilities. The following capabilities shall be provided as a minimum. Manual and remote control access will be selected by a switch located on the front panel.

A. Manual monitoring capability will be available on the HRDM front panel for:

- Power on/off
- Indication of HRDM sync lock status
- Flight number identification, decimal display
- GMT (out of data format) decimal display (seconds, minutes, hours, and days will be displayed)
- Configuration status information, grouped binary display and labeled
- Status of data flow at the inputs and outputs
- Bits synchronization lock status
- Special indicator to display HRM BITE configuration
- Accumulated bit errors in the sync bit error counter, decimal display
- Pass or fail results on self-test.

TABLE I-11

CLOCK REGISTER LOADING

WORD 1, 4, 7	CCCC	AADD	DDDD	64 - DD DDD (BINARY 0-63) = N (SEE BELOW)
WORD 2, 5, 8	CCCC	CCDD	DDDD	65 - DD DDD (BINARY 0-63) = M CCCC CC = CHANNEL NO. PER WORD 1,4 ....+1 (BINARY)
WORD 3, 6, 9	CCCC	CCBD	DDDD	CCCC CC = CHANNEL NO. PER WORD 1,4 ..+1 (BINARY) B = BURST (0) CONTINUOUS (1)

CCCC CC	CHANNEL NO.
0000 01	EXP 1
0001 00	EXP 2
0001 11	EXP 3
0010 10	EXP 4
0011 01	EXP 5
0100 00	EXP 6
0100 11	EXP 7
0101 10	EXP 8
0110 01	EXP 9
0111 00	EXP 10
0111 11	EXP 11
1000 10	EXP 12
1001 01	EXP 13
1010 00	EXP 14
1010 11	EXP 15
1011 10	EXP 16
1100 01	VOICE CHANNEL
1101 00	PLR
1101 11	HDRR
1110 10	I/O 1
1111 01	I/O 2

D - DDDD		= D REGISTER
0	0000	1
1	1000	2
1	1001	4
1	1010	8
1	1011	16
1	1100	32
1	1101	64
1	1110	128
1	1111	256
1	0000	512
1	0001	1024
1	0010	2048
1	0011	4096
1	0100	8192
1	0101	16384
1	0110	32768
1	0111	65536

THE OUTPUT FREQUENCY IS GIVEN AS: OUTPUT FREQ = VREF $\times \frac{M}{ND}$

VREF = 30 MHZ FOR HDRR AND 15 MHZ FOR ALL OTHER CHANNELS

LIMIT OF FREQUENCY (VREF $\times \frac{M}{N}$) 18-40 MHZ (HDRR)
9-20 MHZ (ALL OTHER)

TABLE I-12

RELATIONSHIP OF HRDM TABLE LOADING TO BASIC USER FORMAT

ENG'G WORD 1	SYNC 1 (25)	SYNC 2 (26)	HDRR (19)	HDRR (19)	HDRR (19)	HDRR (19)	E1 (1)	E1 (1)	E1 (1)	E2 (2)	HDRR (19)	HDRR (19)	HDRR (19)	HDRR (19)	E3 (3)	FILL ID (29)	HRDM FORMAT LOAD NO. 1
USER FRAME 0	E3 (3)	E3 (3)													E3 (3)		
	E4 (4)	E4 (4)													E4 (4)		HRDM FORMAT LOAD NO. 2
ENG'G FRAME 1	E5 (5)	E5 (5)													E5 (5)		
FORMAT LOAD WORD 3	VOICE (17)	VOICE (17)													VOICE (17)		HRDM FORMAT LOAD NO. 3
	I/O 1 (20)	I/O 1 (20)	HDRR (19)	HDRR (19)	HDRR (19)	HDRR (19)	E1 (1)	E1 (1)	E1 (1)	E2 (2)	HDRR (19)	HDRR (19)	HDRR (19)	HDRR (19)	I/O 1 (20)	FILL ID (29)	FORMAT LOAD WORD 34

(XX) = HRDM DEVICE NUMBER

	STATUS 1 (27)	STATUS 2 (28)	HDRR (19)	HDRR (19)	HDRR (19)	HDRR (19)	E1 (1)	E1 (1)	E1 (1)	E2 (2)	HDRR (19)	HDRR (19)	HDRR (19)	HDRR (19)	E3 (3)	FILL ID (29)	HRDM FORMAT LOAD NO. 4
USER FRAME 1	E3 (3)	E3 (3)													E3 (3)		
	E4 (4)	E4 (4)													E4 (4)		HRDM FORMAT LOAD NO. 5
ENG'G FRAME 1	E5 (5)	E5 (5)													E5 (5)		
	VOICE (17)	VOICE (17)													VOICE (17)		HRDM FORMAT LOAD NO. 6
	I/O 2 (21)	I/O 2 (21)	HDRR (19)	HDRR (19)	HDRR (19)	HDRR (19)	E1 (1)	E1 (1)	E1 (1)	E2 (2)	HDRR (19)	HDRR (19)	HDRR (19)	HDRR (19)	I/O 2 (21)	FILL ID (29)	ENG'G WORD 192

AA10914(C)-3

TABLE I-13

HRDM FORMAT LOADING EXAMPLE

(FUNCTIONAL CONTENT OF FORMAT WORDS SHOWN INSTEAD OF HEXADECIMAL CODES)

WORD	HRDM FORMAT LOADS NO. 1	NO. 2	NO. 3	NO. 4	NO. 5	NO. 6
1	RAM 1	RAM 1	RAM 1	RAM 1	RAM 1	RAM 1
2	ADDR 0	ADDR 32	ADDR 64	ADDR 96	ADDR 128	ADDR 160
3	25	4	17	27	4	17
4	26	4	17	28	4	17
5	19	19	19	19	19	19
6	19	19	19	19	19	19
7	19	19	19	19	19	19
8	19	19	19	19	19	19
9	1	1	1	1	1	1
10	1	1	1	1	1	1
11	1	1	1	1	1	1
12	2	2	2	2	2	2
13	19	19	19	19	19	19
14	19	19	19	19	19	19
15	19	19	19	19	19	19
16	19	19	19	19	19	19
17	3	4	17	3	4	17
18	29	29	29	29	29	29
19	3	5	20	3	5	21
20	3	5	20	3	5	21
21	19	19	19	19	19	19
22	19	19	19	19	19	19
23	19	19	19	19	19	19
24	19	19	19	19	19	19
25	1	1	1	1	1	1
26	1	1	1	1	1	1

TABLE I-13 (CONT'D)

WORD	HRDM FORMAT LOADS					
	NO. 1	NO. 2	NO. 3	NO. 4	NO. 5	NO. 6
27	1	1	1	1	1	1
28	2	2	2	2	2	2
29	19	19	19	19	19	19
30	19	19	19	19	19	19
31	19	19	19	19	19	19
32	19	19	19	19	19	19
33	3	5	20	3	5	21
34	29	29	29	29	29	29

B. Manual control capability shall include:

- Power on/off (located on power panel)
- Selection of sync pattern (internal switches)
- HRM BITE format data output inhibit on/off
- Self-test on (automatic off)
- Lamp test
- Selection of counting intervals for bit error measurements
- Input data, normal/inverted
- Input data, NRZ-L/NRZ-S
- Input data, bit sync/test (HRM)/test (UT)

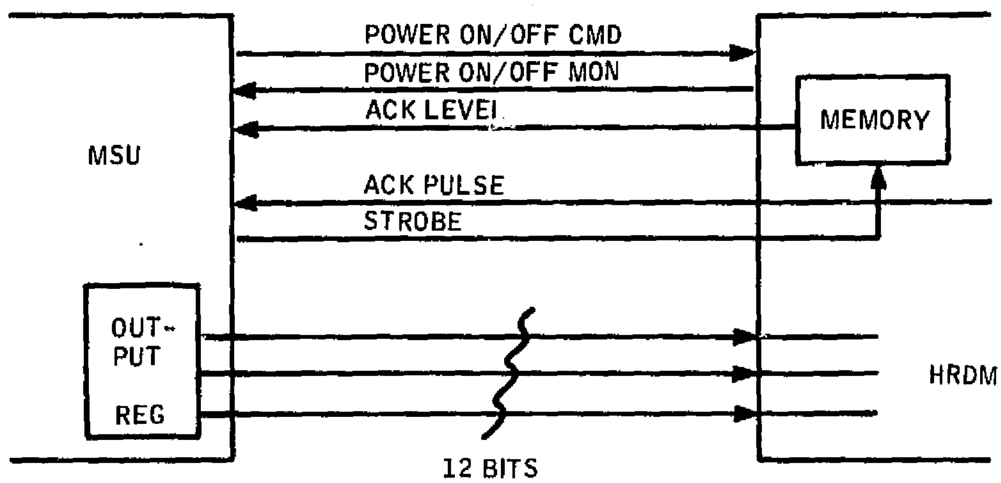
I.3.4.2 Remote Control and Monitoring. See figure I-13.

A. Command Interface. The HRDM is remotely controlled via the MSU by means of discrete command and of parallel data transfer of 12 bits. This parallel data transfer is controlled by two signals, strobe and acknowledge (pulse or level). The HRDM shall provide the two acknowledges (pulse and level even if one only is provided at one time).

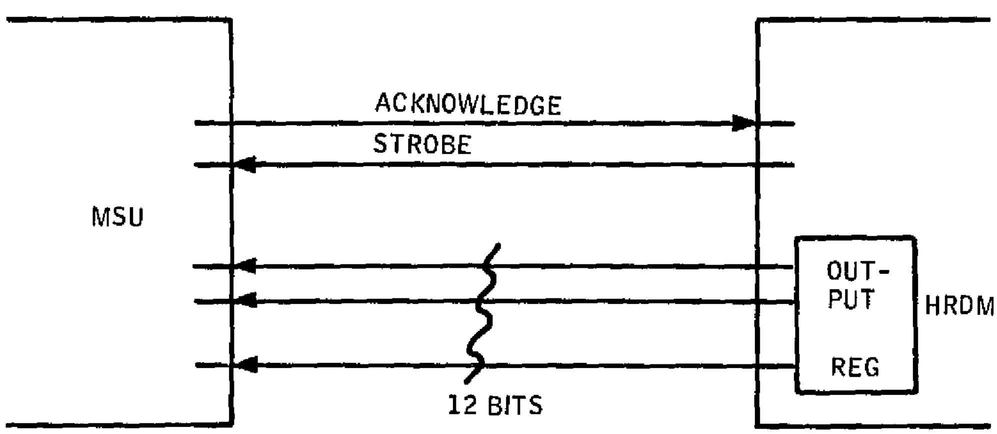
1. Transfer Mechanism. The data words are organized in blocks of 12-bit words of variable length (minimum 1 word, maximum 64 words). The first word of the block is a "header word" which defines what is following, or which can contain the information itself. The header word (12 bits) is divided into two parts. Bits 1-6 are the operational code and bits 7-12 are the block length or data (if data is composed of 6 bits only).

a. Bits 1 and 2

- 00. Single word transmission with input data (in this case, data is contained in bits 7-12)
- 01. Single word transmission read-out request single (request for monitoring single)
- 10. Single word transmission read-out request continuous (request for monitoring continuously)
- 11. Block data transfer (in this se, bits 7-12 contain block length).



COMMAND INTERFACE DIAGRAM



MONITOR INTERFACE DIAGRAM

AA10914(A)-6

Figure I-13 Command/Monitor Interface

b. Bits 3-6. These identify the type of information which is:

- Contained in bits 7-12 if bits 1 and 2 are 00
- Contained in the following words if bits 1 and 2 are 11
- Requested in monitoring if bits 1 and 2 are 10 or 01.

c. Bits 7-12. These bits contain:

- Block length if bits 1 and 2 are 11
- Data if bits 1 and 2 are 00
- Not used if bits 1 and 2 are 01 or 10.

2. Command List for MSU to HRDM

a. Sync pattern selection
b. Format table loading
c. Clock register load
d. Select preprogrammed format
e. Selection of sync BER counting intervals
f. Format defintion table change
g. BITE data output inhibit/enable
h. Conduct self-test
i. Reset BER counter
j. Read-out request for:
   - Selected sync pattern
   - Computer programmable format tables
   - Flight number
   - GMT
   - Configuration status information
   - Status of data flow at the inputs and outputs
   - Sync error counter
   - Frame counter
   - Format definition table.

3. Discrete Commands. In addition to the commands described above, there exists a discrete on/off command transmitted from MSU to HRDM.

- Power ON (logic 1 level)
- Power OFF (logic 0 level).

4. Command Codes. The following command codes (header words) will be accepted and processed by the HRDM: (LSB is bit 12 of the MSU interface).

a. Block Transfers

Sync pattern selection	1101 0100 0111	(LSB)
Format loading	1101 1010 0010	
Clock register loading (RAM 1)	1110 0111 1111	
Clock register loading (RAM 2)	1110 1111 1111	
Format definition table change	1110 0000 0010	
Readout format	1101 1100 0010	

b. Single-Word Transmission With Input Data

Select preprogrammed format	0001 10DD DDDD	(LSB)
Inhibit/enable BITE data output	0001 1110 101D	
Select bit error count interval	0001 0100 1DDD	
Readout format definition table	0011 10DD DDDD	
Conduct self-test	0010 0100 0000	
Reset BER counter	0010 1000 0000	

c. Single-Word Readout Request (For)

Selected sync pattern	1000 1000 0000	(LSB)
Flight Number	1000 1100 0000	
GMT	1001 0000 0000	
Configuration status information	1001 0100 0000	
Data flow status	1001 1000 0000	
Sync word error counter	1001 1100 0000	
Frame counter	1010 0000 0000	

B. Monitor Interface. This interface is basically the same as the command interface where the functions of MSU and HRDM are exchanged. Only one acknowledge pulse is sent by the MSU; the acknowledge level line is not required. Discrete codes will be output by the HRDM as required without a readout request. In addition, the power ON/OFF monitoring line shall be transmitted as a discrete status.

1. Monitoring List. Readout on request:

   - Selected sync pattern
   - Format table
   - Flight number
   - GMT
   - Configuration status information
   - Status of data flow at inputs/outputs
   - Sync error counter
   - Frame counter
   - Format definition table
   - Clock register.

2. Monitor Codes. The following monitor codes (header words) will be transmitted by the HRDM:

   a. Block Transfers

Sync pattern	1100 0100 0111	(LSB)
Format table	1100 1010 0010	
Flight number	1100 1100 0001	
GMT	1101 0000 0100	
Configuration status information	1101 0100 0010	
Data flow status	1101 1000 0010	
Sync error counter	1101 1100 0001	
Format definition table	1110 1000 0001	
Clock register (RAM 1)	1110 1111 1111	
Clock register (RAM 2)	1111 0011 1111	

   b. Single Word Transmissions

Frame count	0000 1000 DDDD	(LSB)
Discrete codes	0000 1100 DDDD	

C. Definition of Block Transmissions for Command/Monitoring

1. Sync Pattern Selection/Selected Sync Pattern. The first line below is the first four bits of sync and the last line is the last four bits of sync.

Word			
1	1011	1100	DDDD
2	1011	1000	DDDD
3	1011	0100	DDDD
4	1011	0000	DDDD
5	1011	1101	DDDD
6	1011	1001	DDDD
7	1011	0101	DDDD

2. Format Loading/Format Table. Refer to paragraph I.3.3.1.

3. Clock Register Loading. Refer to paragraph I.3.3.2.

4. Format Definition Table Change/Format Definition Table. Input of format ID indexing is accomplished in a block length of 2 words.

- Word 1 = 0000 00DD DDDD (format ID from 0-63)
- Word 2 = 1000 00YX XXXX (ADR in format memory; Y = 0 for 16 words per line or 1 for 12 words per line

There are 18 possible memory addresses referenced to the first location for each format. If no format is desired, all 12 bits are set to zero. Addresses are as follows.

PROM	X XXXX	PROM	X XXXX	PROM	X XXXX
1	0 0001	7	0 0111	13	0 1101
2	0 0010	8	0 1000	14	0 1110
3	0 0011	9	0 1001	15	0 1111
4	0 0100	10	0 1010	16	1 0000
5	0 0101	11	0 1011	RAM 1	1 0001
6	0 0110	12	0 1100	RAM 2	1 0010

Readout of the format definition table is performed where DD DDDD is contained in the header word of the request, the header word of the response is 1110 1000 1000 0001, and word 1 of the response is same as word 2 above.

5. Flight Number. Word 1 contains the flight number (two BCD digits, in the form 0000 DDDD DDDD.

6. GMT. This is presented as:

Word		
1	DDDD DDDD DDDD	Year (0-9) + days (0-99) × 10
2	DDDD DDDD DDDD	Day (0-9) + hours (0-23)
3	DDDD DDDD DDDD	Minutes (0-59) + seconds (0-9 × 10) BCD
4	DDDD DDDD DDDD	Seconds ([illegible]99) ÷ 100 BCD

7. Configuration Status Information. Word 1 contains the HRM status word bits 8-19, and word 2 contains the HRM status word bits 20-31, in the form DDDD DDDD DDDD.

8. Data Flow Status. Word 1 is experiment 1-12 and word 2 contains experiment 13-16, voice 1-3, PLR, HDRR, I/O 1 and 2, input, both in the form DDDD DDDD DDDD (1 = data output active).

9. Sync Error Counter. Word 1 contains the power of 10 BCD + 0-99 errors in the form PPPP DDDD DDDD.

D. Definition of Single Word Transmissions. Only the LSB 6 bits (bits 7-12) of the header word are defined here.

1. Select Preprogrammed Format. This is the format ID per paragraph I.3.4.2,A,4, in the form DD DDDD.

2. Select Bit Error Count Interval. This is DDD frames (DDD+3 = power of 10 frames).

3. Frame Count. The frame count for HRM in the form DDDD.

E. Discrete Codes. These are as follows.

DDDD	Response
0001	HRDM BITE data output enabled
0010	HRDM conducting self-test
0110	HRDM self-test GO
0111	HRDM self-test NO-GO
1010	HRDM in sync
1011	HRDM out of sync
1100	HRDM format change

F. Status Word Contents. Figures I-14 and I-15 define the contents of the status words.

1. Change Format Flag. Bit 8 of the configuration status is the change format flag which is used to indicate that a new format is being executed by the HRM. If the flag is set to zero, the format ID corresponds to the format in which the ID is found. If the flag is set to a one, the format ID corresponds to the format that will begin execution at the beginning of frame number zero of the next format. The flag will be set to a 1 for 16 frames; e.g., all the frames of one format.

I.3.5 Format Changes. The requirements for acquisition during format changes are up to 10 frames with frequency change, and up to three frames without frequency change. The second case is, however, dependent on only two factors; one of which is the formula discussed in paragraph I.2.4.2. Basically, if the user allotment is unchanged, no loss of data will occur because the format is executed immediately and the output register is unchanged. If the user allotment is unchanged in rate but the position of his words are changed, then the formula is directly applicable which generally means that no loss of data occurs since extreme formats would have to be used to cause violation.

The case where loss of data may occur is when the total output user race is changed. The HRDM must load the output registers sequentially (at about one channel per word). Since the total HRM rate has not changed, the output register will be loaded during the first line and the beginning of the second. The rule is to load the fastest channels first in order to be able to output data which may be arriving fast during the first line and the output register is still set to a very low output rate which results in overflow. The converse is also true for a channel changing from fast to slow except that an empty could occur but the result is a gap and not loss of data.

If the format is changed with frequency change, then several events add up to a maximum of 10 frames before data is available at the HRDM output. The frequency change occurs at the HRM formatting bus which makes it possible to immediately address user data at the new rates. The data stored in the output formatting FIFO will now be output at the new rate which will probably be lost since the bit synchronizer must first acquire the new rate. (Changing the rate of the HRM at the internal formatting bus is necessary for synchronous changes because a rate change at the output would result in overflow or emptying of the formatting FIFO and loss of data.) After bit synchronizer synchronization (time unknown), the HRDM must acquire a new sync pattern (approximately three frames) and then acquire the format synchronization (up to 768 words or four frames). The four frames required to find the beginning of a user frame is a maximum fixed value but the three frames for sync acquisition is based on probability and can vary. After total acquisition, an additional delay occurs while the output FIFO loads data, but none of this data is lost.

0 – 7	8	9 – 14	15
GMT (BIT 0 = MSB; SEE BELOW)	CHANGE FORMAT FLAG	FORMAT IDENTIFICATION*	PLR ROUT-ING**

*000000 = BITE FORMAT; ALL OTHER = TBD
**0 = OFF (NO SIGNAL OUTPUT); 1 = MUX

FRAME	CONTENT	RANGE
0, 2, AND 4-14	HUNDREDTHS OF SECONDS	0-99
1	SECONDS	0-59
3	MINUTES	0-59
5	HOURS	0-23
7	DAYS	0-99
9	YEAR AND DAY (X 100)	0-9/0-9
11	FLIGHT NO.	0-99
13	SPARE	-
15	SPARE	-

Figure I-14 HRM Configuration Status Word 1

0 – 3	4 – 6	7 – 9	10 – 11	12 – 13	14 – 15
HRM FREQUENCY (MHZ)	HDRR REPRO FREQUENCY (MHZ)	KUSP 48 MHZ ROUTING	KUSP 4 MHZ ROUTING	KUSP 2 MHZ ROUTING	HDRR ROUTING

BITS 0-3	HRM FREQ (MHZ)
0000	0.125
1000	0.250
0100	0.500
1100	1.000
0010	0.125
1010	0.250
0110	0.500
1110	1.000
0001	0.125
1001	1.00
0101	2.0
1101	4.0
0011	8.0
1011	16.0
0111	32.0
1111	48.0

BITS 4-6	HDRR REPRO FREQ (MHZ)
000	2.0
100	4.0
010	8.0
110	12.0
001	16.0
101	24.0
011	32.0
111	

BITS 7-9	KUSP 48 MHz ROUTING
000	OFF
100	OFF
010	OFF
110	OFF
001	DACH NO. 1
101	DACH NO. 2
011	HDRR DIRECT DUMP
111	MUX

BITS 10-11	KUSP (4 MHz) ROUTING
00	OFF
10	PLR DIRECT DUMP
01	HDRR DIRECT DUMP
11	MUX

BITS 12-13	KUSP (2 MHz) ROUTING
00	OFF
10	PLR DIRECT DUMP
01	HDRR DIRECT DUMP
11	MUX

BITS 14-15	HDRR ROUTING
00	REPRO (DATA OFF)
10	DACH NO. 1
01	DACH NO. 2
11	MUX

Figure I-15 HRM Configuration Status Word 2

I.4 DATA FLOW CONSIDERATIONS

The basic philosophy relative to data flow from an Orbiter HRM through the HRDM has not been completely baselined. There are many open questions particularly with regard to configuration control of the HRM/HRDM combination. Listed below are several items identified as potential problem areas.

I.4.1 Burst Mode Data in HRM (Word Pattern Transparency). The following questions and ground processing considerations apply to burst mode data in HRM (word pattern transparency).

A. How will the experiment maintain a constant bandwidth output as the HRM changes formats/bit rates?

B. The interface between the HRM and experiment for the frame pulses and format pulses is not described in the HRM design report.

C. Since the only timing information that the experiment receives occurs at frame rate, how does the experiment transfer more than four words per frame without overflowing the input FIFO's?

D. Will there be experiment format reference ID's embedded in the stream to locate the position of parameters? Unless this is done, it is unclear how experiment formats that extend over several HRM formats can be decommutated at the output of the HRDM.

E. What is the impact of fill data which may result from timing perturbations between the HRM and experiment?

I.4.2 Changing of HRM/HRDM Formats. Changing of HRM/HRDM formats will require close coordination between onboard and ground-based systems to minimize loss of data to experiments not affected by the change. The problem is more complex if an HRM bit rate change occurs as a result of the new format. In this case, the configuration of all frequency sensitive components in the data flow (such as bit synchronizers) will have to be changed. In some cases the operating mode of the KUSP will have to be changed. The following operations are necessary whether or not a bit rate change is involved.

A. Send format change command from ground to S/S CPU.

B. Verify command and receipt.

C. S/S CPU loads and verifies HRM alternate format table.

D. S/S CPU verifies format load to JSC POCC.

E. JSC POCC loads anticipated format into HRDM and verifies that the loading was successful (this step is not necessary if the new format is one which is currently resident in the HRDM PROM).

F. An execute command is transmitted to the S/S CPU and verified.

G. S/S CPU commands HRM to switch format.

H. Verification of HRM switch transmitted to JSC POCC.

I. HRDM will automatically switch to the new format when the change format bit is detected in the HRM bit stream and the format ID has been verified for three successive frames.

J. Verification of the HRDM format change is obtained via the HRDM monitor and control interface.

The method for changing the setup of frequency-sensitive devices such as bit synchronizers has not been established. At present there are no indications that there will be an automatic or remote processor-driven interface. It is assumed at this time that such changes will be manual and will be coordinated via voice loops.

I.4.3 Monitoring and Commanding of HRDM. The design of the HRDM command and monitoring interface is oriented more toward interfacing with a dedicated processing element rather than a major processor such as a 370/168 class computer. Status is available on a frame rate basis (every 60 μs at the highest bit rate). Command acknowledgment can be delayed up to 2 milliseconds. It appears at this time that in order to take advantage of all real-time status available from the HRDM, it will be necessary to incorporate an interface element which can accept status changes in real time and transfer summary messages to a central processing unit. Exceptional status handling can be handled via an interrupt protocol between the dedicated element and the central processing unit.

APPENDIX K

EXPERIMENT COMPUTERS FORMAT

PAGE 1 OF 5

DATA REQUIREMENT

COLS 1-2 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COLS 5-6 (REC NO)	COLS 7-18 (DRF NO. X-XXXXXXX)
01	DRF NUMBER (7-18)		IMPLEMENTER (19-28)			DRF DATE
	H01-B11-000A		JSC			04-15-78
	REQUEST CONTACT (37-50)		RC PHONE (51-62)			REV DATE (63-70)
	A. Jackson		872-0988			09-01-78

ORIGINATOR

02 TITLE (19-20)	DR / MR X / MS
LAST NAME, INITIALS (21-40)	Jackson, A.
03 ORGANIZATION (19-43)	MSFC/EF25
04 A/C (19-21)	205
PHONE NO. (23-30)	453-0988
EXT. (32-35)	
05 (19) 0-NO 1-YES	
SIGNATURE	
DATE (20-27)	- -

CONTACT/DATA RECIPIENT

TITLE (41-42)	DR / MR / MS
LAST NAME, INITIALS (43-62)	
ADDRESS (44-68)	
CITY, STATE, ZIP CODE (36-60)	
A/C (28-30)	
PHONE NO. (32-39)	
EXT. (41-44)	

DRF TYPE	ORIG. / REV. X
DRF NO. (IF REV)	
DATE REQ'D (61-75)	
QUANTITY (45-59)	

06 PROGRAM (19-30)	MISSION (31-44)	PERIOD OF INTEREST (45-68)	SUBS/EXPR (69-80)
SPACELAB	SL-1	FLIGHT	HRM/EXP

07 DRF TITLE (19-78) Pre-Processing Inputs - Experiment Computer I/O

COLS (19-21) (22) (23-112) DETAILED REQUIREMENTS (PUNCH 21 IN COLS 5 THRU 6)

The POCC telemetry processing system shall be capable of receiving, recording, and processing inputs from the HRM/HRDM Experiment Computer I/O channel.

The format and content of the data in the 25.6 KBS Experiment Computer I/O channel is a function of the experiments in operation during a particular time segment of the mission. During each mission time segment the Experiment Computer will gather data from each experiment for inclusion into a predefined format for subsequent transmission to the ground. Each of these formats is a General Measurement Loop Table (GMLT) that resides in a core memory buffer of the Experiment Computer. A portion of the data in the I/O channel has been reserved for use by the operating systems (ECOS/ECAS).

ORIGINATOR ENTRIES

COLS (19-21) (22) (23-112) IMPLEMENTATION COMMENTS (PUNCH 22 IN COLS 5 THRU 8)

	OFF SYM (36-47)	PHONE: AC/NO./EXT (48-64)	DATE (65-72)	SIGNATURE	0-NO 1-YES (73)
08 DRF APPROVAL (19-35)		/ /			
09 IMPLEMENTER (19-35)		/ /			
10 REQ. COMMITMENT (19-35)		/ /			

MSFC - Form 3546 (Rev. March 1977)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18)				
		H01-B11-000A				

(19-21) (22) (23-112)

The data contained in the GMLT will be formatted by the Experiment Computer into a 25.6 KBS data stream and input to the HRM for transmission to the ground. The output of the HRDM will be the 25.6 KBS Experiment Computer formatted data stream as shown in Figure B11-000.1.

The data requirements for the SL-1 experiments using the Experiment Computer I/O channel are summarized in Table B11-000.1. Systems (ECOS/ECAS) data requirements for this channel are summarized in Table B11-000.2. Specific data requirements for each experiment and the operating system using this channel are to be provided on separate DRF's.

MSFC - Form 3646-1 (Rev. March 1971)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18)				
		H01-B11-000 A				

(22) (23-112)

MINOR FRAME	WORD 1		2			4		80
1	24 BIT	SYNC	FC	SOURCE ID	GML ID	DATA	≈	DATA
2	24 BIT	SYNC	FC	MISSION ID		DATA	≈	DATA
3	24 BIT	SYNC	FC	GMT DAY	GMT HRS	DATA	≈	DATA
4	24 BIT	SYNC	FC	GMT MIN	GMT SEC	DATA	≈	DATA
5	24 BIT	SYNC	FC	OPEN	GMT SEC/100	DATA	≈	DATA
6	24 BIT	SYNC	FC	CORRELATION WORD		DATA	≈	DATA
7	24 BIT	SYNC	FC	DATA		DATA	≈	DATA
≈	≈	≈	≈			≈	≈	≈
20	24 BIT	SYNC	FC	DATA		DATA	≈	DATA

(25.6 KBPS HRM FORMAT) FIGURE B11-00.1

MSFC - Form 3586-1 (Rev. March 1977)

PAGE 4 OF 5

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18: EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18) H01-B11-000A				

(1-6) (22) (23-112)

HRDM I/O CHANNEL POCC PROCESSING REQUIREMENTS

TABLE B11-000.1

EXPERIMENT	TELEMETRY							
	DISCRETE			ANALOG			DIGITAL	
	1	10	100	1	10	100	WDS (16 BIT)	RATE S/S
INS001	1						1	A
INS002	17			43	2		1	A
INS003							1	A
INS004	16			1				
INS005				8		5		
INS008				9			3	1
INT011	2			2	2	4	4	1
INT012	1							
INS100							8	1
IES013	5			22			28	1
IES014	7			2				
IES016	3			8			12	1
IES017	1	3		9			4	1
IES019A	1						32	10
IES019B	1						8	1
IES020	5						1	1
IES021	1			7			6	1
IES022	1						2	1
IES023	6			12			9	1
IES024	15			2			1	1
IES027B	4			6				
IES029	2			5				
IEA033	1			16			17	1
IEA034	7			5			22	1
IES200/201	1			2	6			
IES300	2						160	1
IES300							1	A
IES338	1			2				
IES332/333								
AV SWITCH							1	1
AV RECORDER	10			8				
HORIZ SENS	4			4	2			
EPOB	9							
TOTAL	144	3		178	12	9	322	

MSFC - Form 3546-1 (Rev. March 1977)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18) H01-B11-000A				

(19-21) (22) (23-112)

Table B11-000.2

POCC REQUIREMENTS FOR ECOS DOWNLINK
VIA EXPERIMENT COMPUTER I/O CHANNEL

	DATA	DOWNLINK VOLUME (16 BIT WORDS)
1.	HEADER/FORMAT ID (TELEMETRY FORMAT)	1 WORD/ONCE PER SEC
2.	FAULT SUMMARY PAGE	77 WORDS/SEC
3.	SCRATCH PAD LINE	FOR EACH OF 3 DDS's: 25 WORDS/ 2 TIMES PER SEC
4.	GMT	9 WORDS/SEC
5.	MEMORY CONFIGURATION ID	4 WORDS/SEC
6.	LOAD MEMORY/FUNCTIONAL RECONFIGURATION	4 WORDS/SEC
7.	VARIABLE BUFFER (MEMORY DUMP, ECAS MESSAGE)	32 WORDS/SEC
8.	CURRENT DISPLAY ID	FOR EACH OF 3 DDS's: 2 WORDS/SEC
9.	GUIDANCE AND NAVIGATION DATA	48 WORDS/SEC
10.	ECOS TIMELINE STATUS	12-17 WORDS/SEC

NOTE: ECOS TWO STAGE BUFFER (32 WORDS/SEC) NOT REQUIRED IN I/O STREAMS SINCE TWO STAGE BUFFERING IS DONE ONLY IN MOC USING PCMMU DATA.

MSFC - Form 3586-1 (Rev. March 1977)

PAGE 1 OF 10

DATA REQUIREMENT

COLS 1-12 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COLS 5-6 (REC NO)	COLS 7-18 (DRF NO. X-XXXXXXX)
	F					

01 DRF NUMBER (7-18)	IMPLEMENTER (19-28)	DRF DATE (20-26)
H01-B11-001	JSC	09 - 01 - 78
REQUEST CONTACT (37-50)	**RC PHONE (51-62)**	**REV DATE (63-70)**
A. Jackson	872-0988	- -

ORIGINATOR

02	TITLE (19-20)	LAST NAME, INITIALS (21-40)
	DR MR X MS	Jackson, A.
03	ORGANIZATION (19-43)	
	MSFC/EF25	
04	A/C (19-21) (22) PHONE NO. (23-30) (31) EXT (32-35)	
	205 / 453-0988 /	
05	(19) SIGNATURE	DATE (20-27)
0-NO 1-YES		- -

CONTACT/DATA RECIPIENT

TITLE (41-42)	LAST NAME, INITIALS (43-62)
DR MR MS	
ADDRESS (44-68)	
CITY, STATE, ZIP CODE (36-60)	
A/C (28-30) (31) PHONE NO. (32-39) (40) EXT (41-44)	
/ /	

DRF TYPE	
ORIG. x	REV.
DRF NO. (IF REV)	
DATE REQ'D (61-75)	
QUANTITY (45-59)	

06 PROGRAM (19-30)	MISSION (31-44)	PERIOD OF INTEREST (45-68)	SUBS/EXPR (69-80)
SPACELAB	SL-1	FLIGHT	HRM/ECOS/ECAS

07 DRF TITLE (19-78) Pre-Processing inputs I/O - ECOS/ECAS

COLS (19-21) (22) (23-112) **DETAILED REQUIREMENTS** (PUNCH 21 IN COLS 5 THRU 6)

The POCC telemetry preprocessing system shall provide the capability to decommutate the ECOS/ECAS systems data, described in Table B11-000.2, in the Experiment Computer I/O channel.

The decommutated data should be stored in the master telemetry update tables for use by the processing and display systems.

The format and content of the ECOS/ECAS systems data are as follows:

1. Header/Format ID

   TBD

ORIGINATOR ENTRIES

COLS (19-21) (22) (23-112) **IMPLEMENTATION COMMENTS** (PUNCH 22 IN COLS 5 THRU 6)

		OFF SYM (36-47)	PHONE: AC/NO./EXT (48-64)	DATE (65-72)	SIGNATURE	0-NO 1-YES (73)
08	DRF APPROVAL (19-35)		/ /			
09	IMPLEMENTER (19-35)		/ /			
10	REQ. COMMITMENT (19-35)		/ /			

MSFC - Form 3486 (Rev. March 1977)

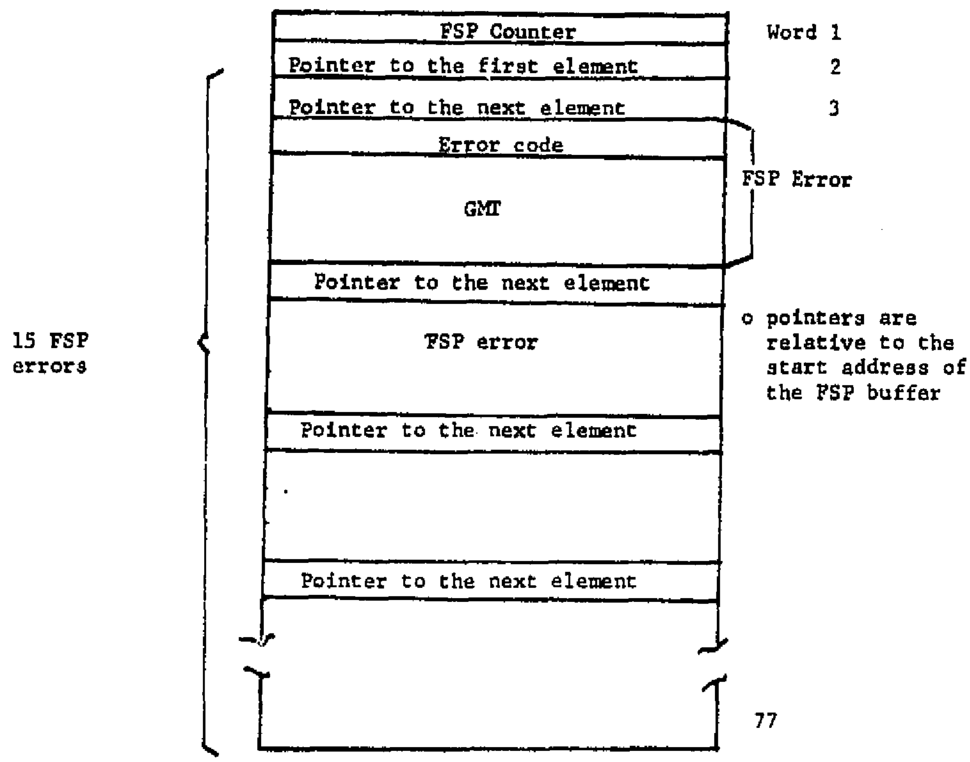
DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18)				
		H01-B11-001				

(22) (23-112)

2. Fault Summary Page

The fault summary page (FSP) is a historical log of error messages. The FSP is logically ordered (by pointers) by time of the errors. FSP content is limited to the latest 15 entries.

The layout of the FSP provided via the HRM/IO link is:



If the pointer to the next element is equal to hexadecimal FFFF, this indicates that the element is the last of the buffer.

The FSP Counter is a 16-bit wraparound counter which is incremented when the date type (FSP) has been updated.

MSFC - Form 3646-1 (Rev. March 1977)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18) H01-B11-001				

(19-21) (22) (23-112)

The FSP is fetched once a second.

Error codes are TBD.

At Initial Program Load (IPL), the FSP is empty, and the Pointer to the first element is hexadecimal FFFF.

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18): H01-B11-001				

(19-21) (22) (23-112)

3. Scratch Pad Lines (SPL)

These buffers represent the Scratch Pad Lines as they are displayed on the Spacelab data display units. There are as many SPL buffers as Spacelab data display systems.

The content of these SPL's is up to 47 ASCII characters (one character per byte). The first word of each SPL includes a count of the number of valid characters displayed.

The SPL layout is as follows:

Acceptance Indicator ("0" indicates acceptance of the message)

Word	0	1 – 7	8 – 15
Word 1		No of valid characters	
2	Character 1		Character 2
3	Character 3		Character 4
25	Character 47		XXXXXXXX

lay out for each DDU

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18) H01-B11-001				

(19-21) (22) (23-112)

4. GMT Buffer

The GMT buffer is provided within the fixed part of the TMB. This buffer is fetched once per second.

The GMT buffer layout is:

	Word				
	1	INDEX			Binary code
	2	DAY	HOUR		
GMT BUFFER "A"	3	MINUTE	SECOND	XX	
	4	X X X X X X X X X	Subframe number		Binary code
	5	CORRELATION REGISTER (EXC)			
	6	DAY	HOUR		
GMT BUFFER "B"	7	MINUTE	SECOND	XX	
	8	X X X X X X X X X	Subframe number		Binary code
	9	CORRELATION REGISTER (EXC)			

MSFC - Form 3546-1 (Rev. March 1977)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18)				
		H01-B11-001				

(19-21) (22) (23-112)

DAY, HOUR, MINUTE, SECOND are in a reduced BCD code derived from the maximum value of the most significant digit (MSD) of each of these data.

e.g., as the maximum value of the MSD of day is 3, only 2 bits are used to code.

The INDEX gives the valid GMT address relative to the start of GMT buffer.

The DAY is the day within the year.

The HOUR, MINUTES & SECONDS give the time within the day.

The subframe number gives the number of 10 milli seconds within a second period.

MSFC - Form 3646-1 (Rev. March 1971)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18) H01-B11-001				

5. Memory Configuration Identifier (MCI)

This data type will be composed of:

- o The memory configuration name (6 characters in ASC II)
- o The MCI counter

The MCI Counter which is a 16-bit wraparound counter will be updated each time a new memory configuration is started (end of load memory configuration command) after the new MC name is ready to be downlinked.

The MCI layout is as follows:

Word 1	MCI Counter	
Word 2	Character 1	Character 2
Word 3	Character 3	Character 4
Word 4	Character 5	Character 6

This identifier will be fetched once a second.

MSFC - Form 3444-1 (Rev. March 1977)

45

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18)				
		H01-B11-001				

(19-21) (22) (23-112)

6. Load Memory, Functional Configuration Request (LFC)

LFC Counter		Word 1
Character 1	Character 2	Word 2
Character 3	Character 4	Word 3
Character 5	Character 6	Word 4

This data type is used to support the Load Memory Configuration command.

LFC Counter: 16 bit wraparound error counter which is incremented when a new request is downlinked.

NAME: 6 character name (ASCII) of the Functional Configuration Table (FCT)/Absolute Memory Image (AMI)/Memory Configuration Table (MCI) to be loaded.

The load configuration request is fetched once a second.

MSFC - Form 3646-1 (Rev. March 1977)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18): H01-B11-001				

(19-21) (22) (23-112)

7. Variable Part

The following data types are included in the variable part:

RI (hexadecimal)	Data Type
2E	Dump data from Spacelab core memory
2F	Dump data from Spacelab MMU
TBD	Application messages
3E	Reserved

This variable part is composed of a 32 word buffer, and is fetched by the PCMMU once per second.

The first word of this buffer is called Serial Transaction Specification word (SISW). This word contains a wraparound counter which is incremented when this data type has been updated.

The second word identifies the contents of words 3 to 32. The structure of this word is the same as the Record Identification Word (RIW).

The data are loaded into the TMB with the following priority: dump data, application messages.

A dump command will be completely executed before another dump command is performed.

MSFC - Form 3646-1 (Rev. March 1977)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18)				
		H01-B11-001				

(19-21) (22) (23-112)

a. Serial Transaction Specification Word

The Serial Transaction Specification Word layout is as follows:

	O/MSB	78	15/LSB
1 word	Wraparound Counter	XXX	Length of Valid Buffer
	$0 \leq N \leq 255$		

b. Dump Data From Core Memory

Following the STSW and the RIW, the next two words acquired through PCMMU during a one second cycle contain the absolute memory address of the first dump word in that frame and the total number of words to be dumped.

Layout of variable part during dump is as follows:

STSW
RIW
Start Address
Total Number of Words
↑ Data Words ↓

MSFC - Form 3646-1 (Rev. March 1977)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		ORF NUMBER (7-18)				
		H01-B11-001				

(19-21) (22) (23-112)

c. Dump Data from MMU

This record is used to support the Dump MMU Block command. In the Dump Data from MMU, RIW is repeated within each Block. The two words after the RIW specify the MMU Tape Position address and the start address of the data words in this record. The start address is specified relative to the beginning of the MMU block. The 512 words are dumped in 19 blocks. The first 18 blocks contain 28 data words and the 19th block contains 8 data words.

The Dump MMU layout is as follows:

STSW
RIW
Start Address
MMU Tape Position Address
Data Words

PAGE 12 OF 16

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18) H01-B11-001				

(19-21) (22) (23-112)

d. Application Program Data/Message

The RIW identifies the application which is sending the data.

The layout is TBD.

MSFC - Form 3646-1 (Rev. March 1977)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18)				
		H01-B11-001				

8. Current Display ID

The current display ID is a four character identification of the format presently displayed on the DDS. These data are downlinked once per second via a six word buffer (3 DDS's 2 words each) as follows:

Character 1	Character 2	Word 1	DDS 1
Character 3	Character 4	Word 2	
Character 1	Character 2	Word 3	DDS 2
Character 3	Character 4	Word 4	
Character 1	Character 2	Word 5	DDS 3
Character 3	Character 4	Word 6	

MSFC - Form 3646-1 (Rev. March 1977)

51

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18)				
		H01-B11-001				

(21) (22) (23-112)

9. GN&C Data

a. Orbiter Position Vector (GTOD)

This record is transmitted by the Orbiter each two seconds to update the Orbiter Position Vector data in S/L.

The AR includes the current Orbiter Position and Velocity vectors in Greenwich Tru of Data (GTOD) Co-ordinate system, as shown below.

RIW	
GMT (secs) double scalar	
Position Vector	X
(3 double scalars) (meters)	Y
	Z
Velocity Vector	X
(3 scalars) (meters/sec)	Y
	Z

23 CDW's

Orbiter Position Vector (GTOD) AR

MSFC - Form 3646-1 (Rev. March 1977)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18)				
		H01-B11-001				

(19-21) (22) (23-112)

b. Orbiter Attitude Vector (GTOD)

This AR is transmitted by the Orbiter each two seconds to update the Orbiter Attitude Vector data in S/L.

The attitude is expressed as Euler Angles and quaternions relative to the Greenwich TOD co-ordinate system, and the attitude rates are measured in the Orbiter body axes. The format of the record is as shown below.

RIW	
GMT (secs) (double scalar)	
Attitude Vector (3 scalars)	
Attitude Rate Vector (3 scalars)	25 CDW's
Attitude Quaternion (4 scalars)	

Orbiter Attitude Vector (GTOD) Record

MSFC - Form 3544-1 (Rev. March 1977)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18)				
		H01-B11-001				

(19-21) (22) (23-112)

10. Timeline Status

The timeline status data consists of up to 17 words per second downlinked from the timeline status buffer via the Experiment Computer I/O to HRM channel. Each word of this buffer represents two ASCII characters.

The format of this buffer is given below:

TBD

MSFC - Form 3584-1 (Rev. March 1977)

PAGE 1 OF 3

DATA REQUIREMENT		
COLS 1-18 EACH RECORD: COL 1 F; COL 2 (AC); COL 3; COL 4; COLS 5-6 (REC NO)		COLS 7-18 (DRF NO. X-XXXXXX)
01 DRF NUMBER (7-18)	IMPLEMENTER (19-28)	DRF DATE (29-36)
H01-B11-002	JSC	09 - 01 - 78
REQUEST CONTACT (37-50)	RC PHONE (51-62)	REV DATE (63-70)
A. Jackson	872-0988	- -

ORIGINATOR	CONTACT/DATA RECIPIENT	
02 TITLE (19-20) LAST NAME, INITIALS (21-40)	TITLE (41-42) LAST NAME, INITIALS (43-62)	DRF TYPE
DR MR x MS Jackson, A.	DR MR MS	ORIG. x REV.
03 ORGANIZATION (19-43)	ADDRESS (44-68)	DRF NO. (IF REV)
MSFC/EF25		
04 A/C (19-21) (22) PHONE NO. (23-30) (31) EXT (32-35)	CITY, STATE, ZIP CODE (36-60)	DATE REQ'D (61-75)
205 / 453-0988 /		
05 (19) SIGNATURE DATE (20-27)	A/C (28-30) (31) PHONE NO. (32-39) (40) EXT (41-44)	QUANTITY (45-59)
0-NO 1-YES - -	/ /	

06 PROGRAM (19-30)	MISSION (31-44)	PERIOD OF INTEREST (45-68)	SUBS/EXPR (69-80)
SPACELAB	SL-1	FLIGHT	HRM/EXP

07 DRF TITLE (19-78) Pre-Processing Inputs I/O - EXP

COLS (13-21) (22) (23-112) DETAILED REQUIREMENTS (PUNCH 21 IN COLS 5 THRU 6)

The Experiment Computer I/O channel, as presently conceived, is used not only for the downlink of housekeeping and systems data, but also as the sole data source for many of the low bit rate experiments. Much of the scientific information on this channel is sampled at a rate less than 1.0 Hz and would therefore require over sampling, sometimes by orders of magnitude, to stay within the baseline format standards of the POCC. It is therefore requested that for SL-1 the POCC provide the capability to allow submultiplexing of experiment science data on the Experiment Computer I/O channel within the following guidelines:

a. Each experiment must provide a subframe identifier (major frame counter) as the first data word in a submultiplexed channel. The major frame counter shall be located in a single fixed (word and frame) location in each experiment I/O major frame.

b. Each submultiplexed parameter must be unambiguously identified by the use of the subframe ID and the minor frame counter.

ORIGINATOR ENTRIES

COLS (19-21) (22) (23-112) IMPLEMENTATION COMMENTS (PUNCH 22 IN COLS 5 THRU 6)

	OFF SYM (36-47)	PHONE: AC/NO./EXT (48-64)	DATE (65-72)	SIGNATURE	0-NO 1-YES
08 DRF APPROVAL (19-35)		/ /			(73)
09 IMPLEMENTER (19-35)		/ /			(73)
10 REQ. COMMITMENT (19-35)		/ /			(73)

MSFC - Form 3646 (Rev. March 1977)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18) H01-B11-002				

(19-21) (22) (23-112)

c. All submultiplexed channels must be synchronized with the Experiment Computer I/O major frame.

d. All submultiplexed formats shall be premission defined.

e. The submultiplexed data cycle shall not exceed 60 Experiment Computer I/O channel major frames (1.0) minutes).

f. No more than four submultiplexed formats from a given Experiment Computer I/O format.

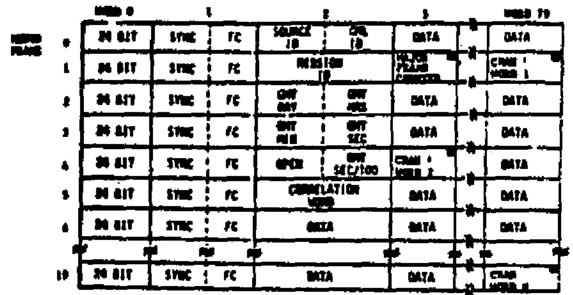
g. Strip chart recording of submultiplexed data shall not be required in the POCC.

Figure B11-002.1 is an example of how an experimenter may submultiplex data in the I/O channel with those data words with black boxes in the upper right most corner in each major frame representing submultiplexed channels 1, 2, .. N. Minor frame 1 word 3 of each major frame shows the experimenter provided subframe ID (major frame counter) used to identify the submultiplexed channel in the major frame.

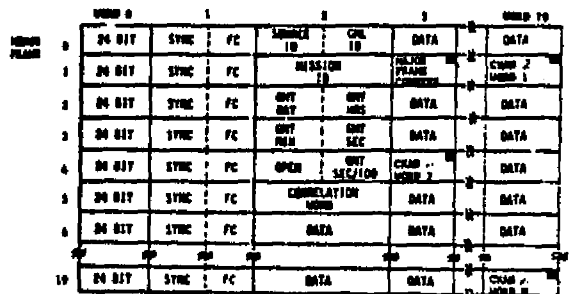
MSFC - Form 3646-1 (Rev. March 1977)

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18)				
		H01-B11-002				

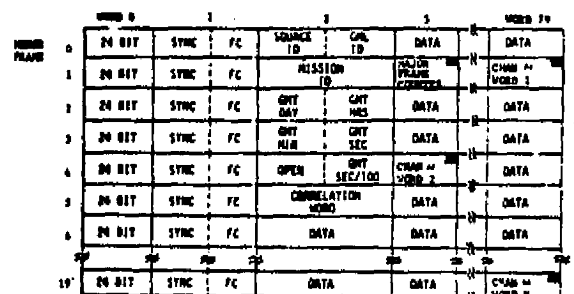
(19-21) (22) (23-112)



MAJOR FRAME 1



MAJOR FRAME 2



MAJOR FRAME 3

EXPERIMENT I/O CHANNEL
SUBMULTIPLEXING
FIGURE B11-002.1

MSFC - Form 3688-1 (Rev. March 1977)

PAGE 1 OF 2

DATA REQUIREMENT

COLS 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COLS 5-6 (REC NO)	COLS 7-13 (DRF NO. X-XXXXXX)
	*					

01 DRF NUMBER (7-18)	IMPLEMENTER (19-28)	DRF DATE (29-36)
H01-B11-010	JSC	09 - 01 - 78
REQUEST CONTACT (37-50)	RC PHONE (51-62)	REV DATE (63-70)
A. Jackson	872-0988	- -

ORIGINATOR	CONTACT/DATA RECIPIENT	
02 TITLE (19-20) DR MR MS — LAST NAME, INITIALS (21-40)	TITLE (41-42) DR MR MS — LAST NAME, INITIALS (43-62)	DRF TYPE: ORIG. x REV.
03 ORGANIZATION (19-43)	ADDRESS (44-68)	DRF NO. (IF REV)
04 A/C (19-21) (22) PHONE NO. (23-30) (31) EXT (32-35): / /	CITY, STATE, ZIP CODE (36-60)	DATE REQ'D (61-75)
05 (19) 0-NO 1-YES SIGNATURE — DATE (20-27) - -	A/C (28-30) (31) PHONE NO. (32-39) (40) EXT (41-44): / /	QUANTITY (45-59)

06 PROGRAM (19-30)	MISSION (31-44)	PERIOD OF INTEREST (45-68)	SUBS/EXPR (69-80)
SPACELAB	SL-1	FLIGHT	HRM/1NS001

07 DRF TITLE (19-78) Pre-Processing Inputs I/O - 1NS001

COLS (19-21) (22) (23-112) DETAILED REQUIREMENTS (PUNCH 21 IN COLS 5 THRU 6)

The 1NS001 experiment has 1 discrete measurement in the Experiment Computer I/O channel output of the HRDM. This discrete parameter indicates the on/off status of the instrument. The basic POCC processing requirements for this measurement are summarized in Table B11-010.1.

ORIGINATOR ENTRIES

COLS (19-21) (22) (23-112) IMPLEMENTATION COMMENTS (PUNCH 22 IN COLS 5 THRU 6)

	OFF SYM (36-47)	PHONE: AC/NO./EXT (48-64)	DATE (65-72)	SIGNATURE	0-NO 1-YES (73)
08 DRF APPROVAL (19-35)		/ /			
09 IMPLEMENTER (19-35)		/ /			
10 REQ. COMMITMENT (19-35)		/ /			

TABLE B11-010.1

POCC TELEMETRY PROCESSING FOR EXPERIMENT INS001

ID	DESCRIPTION	CHANNEL	SPS	TYPE	NO. BITS	POCC PROCESSING REQUIREMENT		POCC DISPLAY REQUIREMENTS	
						DELAY TIME	PROCESSING REQUIREMENT	DISPLAY DEVICE	FORMAT/TEXT
1.	EXP STATUS	ECOC	1	D	1	RT			

PAGE 1 OF 3

DATA REQUIREMENT	COLS 1-13 EACH RECORD	COL 1 #	COL 2 (AC)	COL 3	COL 4	COLS 5-6 (REC NO)	COLS 7-18 (DRF NO. X-XXXXXX)
	01 DRF NUMBER (7-18)		IMPLEMENTER (19-28)				DRF DATE (29-36)
	H01-B11-020		JSC				09 - 01 - 78
	REQUEST CONTACT (37-50)		RC PHONE (51-62)				REV DATE (63-70)
	A. Jackson		872-0988				- -

ORIGINATOR	CONTACT/DATA RECIPIENT	
02 TITLE (19-20) LAST NAME, INITIALS (21-40) DR MR MS	TITLE (41-42) LAST NAME, INITIALS (43-62) DR MR MS	DRF TYPE ORIG. x REV.
03 ORGANIZATION (19-43)	ADDRESS (44-68)	DRF NO. (IF REV)
04 A/C (19-21) (22) PHONE NO. (23-30) (31) EXT (32-35) / /	CITY, STATE, ZIP CODE (36-60)	DATE REQ'D (61-75)
05 (19) 0-NO 1-YES SIGNATURE DATE (20-27) - -	A/C (28-30) (31) PHONE NO. (32-39) (40) EXT (41-44) / /	QUANTITY (45-59)

06 PROGRAM (19-30)	MISSION (31-44)	PERIOD OF INTEREST (45-68)	SUBS/EXPR (69-80)
SPACELAB	SL-1	FLIGHT	HRM/1NS002

07 DRF TITLE (19-78) Pre-Processing Inputs I/O - 1NS002

COLS (19-21) (22) (23-112) DETAILED REQUIREMENTS (PUNCH 21 IN COLS 5 THRU 6)

The 1NS002 telemetry data in the Experiment Computer I/O channel consists of 45 analog parameters (43 at 1 SPS and 2 at 10 SPS) and 17 discretes at 1 SPS.

The 1NS002 measurements and basic POCC processing requirements are summarized in Table B11-020.1.

ORIGINATOR ENTRIES

COLS (19-21) (22) (23-112) IMPLEMENTATION COMMENTS (PUNCH 22 IN COLS 5 THRU 6)

	OFF SYM (36-47)	PHONE: AC/NO./EXT (48-64)	DATE (65-72)	SIGNATURE	0-NO 1-YES (73)
08 DRF APPROVAL (19-35)		/ /			
09 IMPLEMENTER (19-35)		/ /			
10 REQ. COMMITMENT (19-35)		/ /			

MSFC - Form 3544 (Rev. March 1974)

Table B11-020.1
POCC TELEMETRY PROCESSING FOR EXPERIMENT INS002

ID	DESCRIPTION	CHANNEL	SPS	TYPE	NO. BITS	POCC PROCESSING REQUIREMENT: DELAY TIME	POCC PROCESSING REQUIREMENT: PROCESSING REQUIREMENT	POCC DISPLAY REQUIREMENTS: DISPLAY DEVICE	POCC DISPLAY REQUIREMENTS: FORMAT/TEXT
1	HVCINC	EC	1	A	8	RT			
2	BATT 1								
3	BATT 2								
4	BATT 3								
5	BATT 4								
6	BATV 1								
7	BATV 2								
8	BATV 3								
9	BATV 4								
10	BATV 5								
11	BATV 6								
12	BATV 7								
13	BATV 8								
14	BATV 9								
15	BATV 10								
16	BATV 11								
17	BATV 12								
18	BATV 13								
19	BATV 14								
20	BATV 15								
21	BATV 16								
22	HGC 1								
23	HGC 2								
24	HGT 1								
25	EBAT 4								
26	GPST 1								
27	HVCT 1								
28	MPDT 1								
29	TEMP 1								
30	DPSTIM		1						
31	FPLMMN		10						
32	EPVHGD	EC	1	A	8	RT			

TABLE B11-020.1

Table B11-020.1

POCC TELEMETRY PROCESSING FOR EXPERIMENT INS002

ID	DESCRIPTION	CHANNEL	SPS	TYPE	NO. BITS	POCC PROCESSING REQUIREMENT		POCC DISPLAY REQUIREMENTS	
						DELAY TIME	PROCESSING REQUIREMENT	DISPLAY DEVICE	FORMAT/TEXT
33	BODYCH	EC	10	A	8	RT			
34	HVCINV		1						
35	PHOT 2								
36	PWLTMP								
37	IU 28V								
38	IU 5V								
39	IU 15V								
40	IUM 15V								
41	IU 28C								
42	IU 5C								
43	IUENT								
44	IUBMT								
45	IUSET		1	A	8				
46	BATUV		1	D	1				
47	HVCAB 1								
48	HVCAB 2								
49	HVCAB 3								
50	HVCAB 4								
51	HVCAB 5								
52	HVCAB 6								
53	MODOLD								
54	FAVSCR								
55	PISTON								
56	FAVC								
57	TRGSCR								
58	TRGC								
59	BATSWS								
60	HVCOLD								
61	HTROLD								
62	MISFIR	EC	1	D	1	RT			

TABLE B11-020.1

PAGE 1 OF 3

DATA REQUIREMENT

COLS 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COLS 5-6 (REC NO)	COLS 7-18 (DRF NO. X-XXXXXX)

01 DRF NUMBER (7-18)	IMPLEMENTER (19-28)	DRF DATE (29-36)
H01-B11-030	JSC	09 - 01 - 78
REQUEST CONTACT (37-50)	**RC PHONE (51-62)**	**REV DATE (63-70)**
A. Jackson	872-0988	- -

ORIGINATOR	CONTACT/DATA RECIPIENT	
02 TITLE (19-20) DR MR MS; LAST NAME, INITIALS (21-40)	TITLE (41-42) DR MR MS; LAST NAME, INITIALS (43-62)	DRF TYPE: ORIG. X REV.
03 ORGANIZATION (19-43)	ADDRESS (44-68)	DRF NO. (IF REV)
04 A/C (19-21) (22) PHONE NO. (23-30) (31) EXT (32-35)	CITY, STATE, ZIP CODE (36-60)	DATE REQ'D (61-75)
05 (19) 0-NO 1-YES SIGNATURE; DATE (20-27) - -	A/C (28-30) (31) PHONE NO. (32-39) (40) EXT (41-44)	QUANTITY (45-59)

06 PROGRAM (19-30)	MISSION (31-44)	PERIOD OF INTEREST (45-68)	SUBS/EXPR (69-80)
SPACELAB	SL-1	FLIGHT	HRM/1NS003

07 DRF TITLE (19-78) Pre-Processing Inputs I/O - 1NS003

COLS (19-21) (22) (23-112) DETAILED REQUIREMENTS (PUNCH 21 IN COLS 5 THRU 6)

The 1NS003 telemetry inputs on the Experiment Computer I/O channel consist of 35 digital parameters downlinked once per second.

Table B11-030.1 summarizes the input parameters and the basic POCC processing requirements for these data.

ORIGINATOR ENTRIES

COLS (19-21) (22) (23-112) IMPLEMENTATION COMMENTS (PUNCH 22 IN COLS 5 THRU 6)

	OFF SYM (36-47)	PHONE: AC/NO./EXT (48-64)	DATE (65-72)	SIGNATURE	0-NO 1-YES (73)
08 DRF APPROVAL (19-35)		/ /			
09 IMPLEMENTER (19-35)		/ /			
10 REQ. COMMITMENT (19-35)		/ /			

MSFC - Form 3556 (Rev. March 1977)

TABLE B11-030.1
POCC TELEMETRY PROCESSING FOR EXPERIMENT 1NS003

ID	DESCRIPTION	CHANNEL	SPS	TYPE	NO. BITS	POCC PROCESSING REQUIREMENT		POCC DISPLAY REQUIREMENTS	
						DELAY TIME	PROCESSING REQUIREMENT	DISPLAY DEVICE	FORMAT/TEXT
1.	EMERGENCY PARK	ECOC	1	D	1	RT			
2.	MOUNT CHECK	ECOC	1	D	1	RT			
3.	SW CHECK	ECOC	1	D	1	RT			
4.	RUN	ECOC	1	D	1	RT			
5.	HALT	ECOC	1	D	1	RT			
6.	START	ECOC	1	1	1	RT			
7.	EDIT	ECOC	1	D	2	RT			
8.	SELF DUMP	ECOC	1	D	1	RT			
9.	SW RELOAD	ECOC	1	D	1	RT			
10.	CALIBRATE	ECOC	1	D	1	RT			
11.	FO TIME 1	ECOC	1	D	32	RT			
12.	FO TIME 2	ECOC	1	D	32	RT			
13.	FO TIME 3	ECOC	1	D	32	RT			
14.	FO TIME 4	ECOC	1	D	32	RT			
15.	FO TIME 5	ECOC	1	D	32	RT			
16.	FO TIME 6	ECOC	1	D	32	RT			
17.	FO TIME 7	ECOC	1	D	32	RT			
18.	FO TIME 8	ECOC	1	D	32	RT			

TABLE B11-030.1 (Continued)

POCC TELEMETRY PROCESSING FOR EXPERIMENT 1NS003

ID	DESCRIPTION	CHANNEL	SPS	TYPE	NO. BITS	POCC PROCESSING REQUIREMENT		POCC DISPLAY REQUIREMENTS	
						DELAY TIME	PROCESSING REQUIREMENT	DISPLAY DEVICE	FORMAT/TEXT
19.	FWO	ECOC	1	D	8	RT			
20.	FW 1	ECOC	1	D	8	RT			
21.	FW 2	ECOC	1	D	8	RT			
22.	FOV	ECOC	1	D	4	RT			
23.	FOCUS	ECOC	1	D	8	RT			
24.	CAM HV	ECOC	1	D	4	RT			
25.	PCA HV	ECOC	1	D	4	RT			
26.	EXP TIME	ECOC	1	D	4	RT			
27.	TRACK	ECOC	1	D	1	RT			
28.	SPARE	ECOC	1	D		RT			
29.	MPD DELAY	ECOC	1	D	8	RT			
30.	SPARE	ECOC	1	D		RT			
31.	EDIT ADD	ECOC	1	D	16	RT			
32.	EDIT CONTENT	ECOC	1	D	16	RT			
33.	FO	ECOC	1	D	8	RT			
34.	GET H	ECOC	1	D	8	RT			
35.	GET M	ECOC	1	D	8	RT			
36.	GET S	ECOC	1	D	8	RT			

PAGE 1 OF 2

DATA REQUIREMENT

COLS 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COLS 5-6 (REC NO)	COLS 7-18 (DRF NO. X-XXXXXX)
	F					

01	DRF NUMBER (7-18)	IMPLEMENTER (19-28)	DRF DATE (29-36)
	H01-B11-040	JSC	09 - 01 - 78
	REQUEST CONTACT (37-50)	RC PHONE (51-62)	REV DATE (63-70)
	A. Jackson	872-0988	- -

ORIGINATOR	CONTACT/DATA RECIPIENT	
02 TITLE (19-20) DR MR MS; LAST NAME, INITIALS (21-40)	TITLE (41-42) DR MR MS; LAST NAME, INITIALS (43-62)	DRF TYPE: ORIG. X REV.
03 ORGANIZATION (19-43)	ADDRESS (44-68)	DRF NO. (IF REV)
04 A/C (19-21) (22) PHONE NO. (23-30) (31) EXT (32-35) / /	CITY, STATE, ZIP CODE (36-60)	DATE REQ'D (61-75)
05 (19) 0-NO 1-YES SIGNATURE; DATE (20-27) - -	A/C (28-30) (31) PHONE NO. (32-39) (40) EXT (41-44) / /	QUANTITY (45-59)

06 PROGRAM (19-30)	MISSION (31-44)	PERIOD OF INTEREST (45-68)	SUBS/EXPR (69-80)
SPACELAB	SL-1	FLIGHT	HRM/1NS004

07 DRF TITLE (19-78) Preprocessing Inputs I/O - 1NS004

ORIGINATOR ENTRIES

COLS (19-21) (22) (23-112) DETAILED REQUIREMENTS (PUNCH 21 IN COLS 5 THRU 6)

The 1NS004 telemetry data in the Experiment Computer I/O channel consist of 1 discrete parameter sampled twice per second, 1 digital parameter sampled twice per second, and 1 analog parameter sampled once per second.

The 1NS004 measurements and basic POCC processing requirements are summarized in Table B11-040.1.

COLS (19-21) (22) (23-112) IMPLEMENTATION COMMENTS (PUNCH 22 IN COLS 5 THRU 6)

	OFF SYM (36-47)	PHONE: AC/NO./EXT (48-64)	DATE (65-72)	SIGNATURE	0-NO 1-YES (73)
08 DRF APPROVAL (19-35)		/ /			
09 IMPLEMENTER (19-35)		/ /			
10 REQ. COMMITMENT (19-35)		/ /			

MSFC - Form 3544 (Rev. March 1971)

DRF #H01-B11-040
Page 2 of 2

TABLE B11-040.1

POCC TELEMETRY PROCESSING FOR EXPERIMENT INS004

ID	DESCRIPTION	CHANNEL	SPS	TYPE	NO. BITS	POCC PROCESSING REQUIREMENTS		POCC DISPLAY REQUIREMENTS	
						DELAY TIME	PROCESSING REQUIREMENTS	DISPLAY DEVICE	FORMAT/TEXT
1.	Encoder Status	ECOC	2	D	1	NRT			
2.	Shaft Position	ECOC	2	D	16	NRT			
3.	Temperature	ECOC	1	A	8	NRT			

PAGE 1 OF 2

DATA REQUIREMENT

COLS 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COLS 5 & 6 (REC NO)	COLS 7-18 (DRF NO. X-XXXXXX)
	F					

01 DRF NUMBER (7-18)	IMPLEMENTER (19-28)	DRF DATE (29-36)
H01-B11-050	JSC	09 -01 - 78

REQUEST CONTACT (37-50)	RC PHONE (51-62)	REV DATE (63-70)
A. Jackson	872-0988	- -

ORIGINATOR	CONTACT/DATA RECIPIENT	
02 TITLE (19-20) DR MR MS LAST NAME, INITIALS (21-40)	TITLE (41-42) DR MR MS LAST NAME, INITIALS (43-62)	DRF TYPE ORIG. x REV.
03 ORGANIZATION (19-43)	ADDRESS (44-68)	DRF NO. (IF REV)
04 A/C (19-21) (22) PHONE NO. (23-30) (31) EXT (32-35) / /	CITY, STATE, ZIP CODE (36-60)	DATE REQ'D (61-75)
05 (19) 0-NO 1-YES SIGNATURE DATE (20-27) - -	A/C (28-30) (31) PHONE NO. (32-39) (40) EXT (41-44) / /	QUANTITY (45-59)

06 PROGRAM (19-30)	MISSION (31-44)	PERIOD OF INTEREST (45-68)	SUBS/EXPR (69-80)
SPACELAB	SL-1	FLIGHT	HRM/1NS005

07 DRF TITLE (19-78) Preprocessing Inputs I/O - INS005

COLS (19-21) (22) (23-112) DETAILED REQUIREMENTS (PUNCH 21 IN COLS 5 THRU 6)

The 1NS005 downlink telemetry inputs to the POCC are totally contained in the Experiment Computer I/O channel of the HRDM.

These data consist of 5 analogs at 100 samples per second and 8 analogs at 1 sample per second.

The 1NS005 measurements and basic POCC processing requirements are summarized in Table B11-050.1.

ORIGINATOR ENTRIES

COLS (19-21) (22) (23-112) IMPLEMENTATION COMMENTS (PUNCH 22 IN COLS 5 THRU 6)

	OFF SYM (36-47)	PHONE: AC/NO./EXT (48-64)	DATE (65-72)	SIGNATURE	0-NO 1-YES (73)
08 DRF APPROVAL (19-35)		/ /			
09 IMPLEMENTER (19-35)		/ /			
10 REQ. COMMITMENT (19-35)		/ /			

MSFC - Form 3544 (Rev. March 1977)

TABLE B11-050.1

POCC TELEMETRY PROCESSING FOR EXPERIMENT INS005

ID	DESCRIPTION	CHANNEL	SPS	TYPE	NO. BITS	POCC PROCESSING REQUIREMENTS		POCC DISPLAY REQUIREMENTS	
						DELAY TIME	PROCESSING REQUIREMENTS	DISPLAY DEVICE	FORMAT/TEXT
1.	High Voltage	ECOC	100	A	8	RT			
2.	Film Contact	ECOC	100	A	8	RT			
3.	Film Advance	ECOC	100	A	8	RT			
4.	Camera Current	ECOC	100	A	8	RT			
5.	Door Current	ECOC	100	A	8	RT			
6.	Operating Current	ECOC	1.0	A	8	RT			
7.	Standby Current	ECOC	1.0	A	8	RT			
8.	Optics Temperature	ECOC	1.0	A	8	RT			
9.	Detector Temperature	ECOC	1.0	A	8	RT			
10.	Pressure	ECOC	1.0	A	8	RT			
11.	Door Position	ECOC	1.0	A	8	RT			
12.	Camera Motor Volt	ECOC	1.0	A	8	RT			
13.	Door Current Rod	ECOC	1.0	A	8	RT			

PAGE 1 OF 6

DATA REQUIREMENT

COLS 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COLS 5-6 (REC NO)	COLS 7-13 (DRF NO. X-XXXXXX)
	F					

01 DRF NUMBER (7-18)	IMPLEMENTER (19-28)	DRF DATE (29-36)
H01-B11-080	JSC	09 - 01 - 78
REQUEST CONTACT (37-50)	**RC PHONE (51-62)**	**REV DATE (63-70)**
A. Jackson	872-0988	- -

ORIGINATOR		CONTACT/DATA RECIPIENT		
02 TITLE (19-20) DR MR MS	LAST NAME, INITIALS (21-40)	TITLE (41-42) DR MR MS	LAST NAME, INITIALS (43-62)	DRF TYPE: ORIG. x REV.
03 ORGANIZATION (19-43)		ADDRESS (44-68)		DRF NO. (IF REV)
04 A/C (19-21) (22) PHONE NO. (23-30) (31) EXT (32-35)		CITY, STATE, ZIP CODE (36-60)		DATE REQ'D (61-75)
05 (19) 0-NO 1-YES SIGNATURE	DATE (20-27)	A/C (28-30) (31) PHONE NO. (32-39) (40) EXT. (41-44)		QUANTITY (45-59)

06 PROGRAM (19-30)	MISSION (31-44)	PERIOD OF INTEREST (45-68)	SUBS/EXPR (69-80)
SPACELAB	SL-1	FLIGHT	HRM/1NA008

07 DRF TITLE (19-78): Pre-Processing Inputs I/O - 1NA008

COLS (19-21) (22) (23-112) DETAILED REQUIREMENTS (PUNCH 21 IN COLS 5 THRU 6)

The 1NS008 downlink telemetry inputs to the POCC are totally contained in the Experiment Computer I/O channel.

These data consist of 9 analog measurements sampled once per second and a serial PCM channel submultiplexed over 8 major frames containing 28 measurements. The submultiplexed data are transferred at 8 words per second and formatted as shown in Figure B11-080.1. Figure B11-080.2 describes the format of each of the submultiplexed words for the 8 major frames.

A description of the 1NS008 data and the basic POCC processing requirements are summarized in Table B11-080.1.

ORIGINATOR ENTRIES

COLS (19-21) (22) (23-112) IMPLEMENTATION COMMENTS (PUNCH 22 IN COLS 5 THRU 6)

		OFF SYM (36-47)	PHONE: AC/NO./EXT (48-64)	DATE (65-72)	SIGNATURE	0-NO 1-YES (73)
08	DRF APPROVAL (19-35)		/ /			
09	IMPLEMENTER (19-35)		/ /			
10	REQ. COMMITMENT (19-35)		/ /			

MSFC - Form 3556 (Rev. March 1977)

					PAGE 2 OF 6
DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18) H01-B11-080				

(19-21) (22) (23-112)

BLOCK - MAJOR FRAME

	0	1	2	3	4	5	6	7
BLOCK 0	COMMAND ECHO	ST-1	ST-2	ST-3	ST-4	A1	A2	A3
	8	9	10	11	12	13	14	15
BLOCK 1	REF-HI	ST-5	ST-6	ST-7	ST-8	A1	A2	A3
	16	17	18	19	20	21	22	23
BLOCK 2	REF-LO	ST-9	ST-10	ST-11	ST-12	A1	A2	A3
	24	25	26	27	28	29	30	31
BLOCK 3	+10V	ST-13	ST-14	ST-15	ST-16	A1	A2	A3
	32	33	34	35	36	37	38	39
BLOCK 4	+12V	ST-1	ST-2	ST-3	ST-4	A1	A2	A3
	40	41	42	43	44	45	46	47
BLOCK 5	+5V	ST-5	ST-6	ST-7	ST-8	A1	A2	A3
	48	49	50	51	52	53	54	55
BLOCK 6	−12V	ST-9	ST-10	ST-11	ST-12	A1	A2	A3
	56	57	58	59	60	61	62	63
BLOCK 7	VRT	ST-13	ST-14	ST-15	ST-16	A1	A2	A3

WORD #
SIGNAL NAME

FIGURE B11-080.1 SPACELAB/ACR MAJOR FRAME TELEMETRY FORMAT

MSFC - Form 3566-1 (Rev. March 1977)

PAGE 3 OF 5

DATA REQUIREMENT CONTINUATION FOR DETAIL REQUIREMENTS	COL 1-18 EACH RECORD	COL 1	COL 2 (AC)	COL 3	COL 4	COL 5-6
		F				21
		DRF NUMBER (7-18) H01-B11-080				

(19-21) (22) (23-112)

COMMAND ECHO WORD FORMAT

BIT	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DATA	I_3	I_2	I_1	S_A	S_B	S_C	M	P	0	0	0	0	0	0	0	0

M = COMMAND WORD BIT 14 (AUTO/MANUAL)
S_C = COMMAND WORD BIT 13 (SHUTTER C)
S_B = COMMAND WORD BIT 12 (SHUTTER B)
S_A = COMMAND WORD BIT 11 (SHUTTER A)
BIT 0 IS THE FIRST BIT TRANSFERRED
I_1, I_2, I_3 = DATA WORD BLOCK ID
P = INSTRUMENT PHASE DATA
0 = OBSERVATION PHASE
1 = REFERENCE PHASE

MEASUREMENT DATA WORD FORMAT

BIT	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DATA	I_3	I_2	I_1	← A/D CONVERTER DATA →												

BIT 15 IS THE A/D WORD LSB
I_1, I_2, I_3 = DATA WORD BLOCK ID
BIT 0 IS THE FIRST BIT TRANSFERRED

DATA WORD BLOCK ID TABLE

MAJOR FRAME COUNTER	I_1	I_2	I_3	WORD #'S
0	0	0	0	0 THROUGH 7
1	1	0	0	8 THROUGH 15
2	0	1	0	16 THROUGH 23
3	1	1	0	24 THROUGH 31
4	0	0	1	32 THROUGH 39
5	1	0	1	40 THROUGH 47
6	0	1	1	48 THROUGH 55
7	1	1	1	56 THROUGH 63

FIGURE B11-080.2 SPACELAB/ACR SCIENCE DATA BIT FORMAT

MSFC - Form 3646-1 (Rev. March 1977)

TABLE B1[illegible]080.1

POCC TELEMETRY PROCESSING FOR EXPERIMENT 1NA008

ID	DESCRIPTION	CHANNEL	SPS	TYPE	NO. BITS	POCC PROCESSING REQUIREMENTS		POCC DISPLAY REQUIREMENTS	
						DELAY TIME	PROCESSING REQUIREMENTS	DISPLAY DEVICE	FORMAT/TEXT
1.	MT-1	ECOC	1	A	8	RT			
2.	MT-2	ECOC	1	A	8	RT			
3.	MT-3	ECOC	1	A	8	RT			
4.	MT-4	ECOC	1	A	8	RT			
5.	ET-1	ECOC	1	A	8	RT			
6.	ET-2	ECOC	1	A	8	RT			
7.	ET-3	ECOC	1	A	8	RT			
8.	ET-4	ECOC	1	A	8	RT			
9.	+5VA	ECOC	1	A	8	RT			
10.	MFCT-1	ECOC		D/S	3	RT			
11.	CMD/ECHO	ECOC	1/8	D/S	13	RT			
12.	REF-HI	ECOC	1/8	A/S	13	RT			
13.	REF-LO	ECOC	1/8	A/S	13	RT			
14.	+10V	ECOC	1/8	A/S	13	RT			
15.	+12V	ECOC	1/8	A/S	13	RT			
16.	+5V	ECOC	1/8	A/S	13	RT			
17.	-12V	ECOC	1/8	A/S	13	RT			
18.	VRT	ECOC	1/8	A/S	13	RT			

TABLE B11-080.1(Continued)

POCC TELEMETRY PROCESSING FOR EXPERIMENT 1NA008

ID	DESCRIPTION	CHANNEL	SPS	TYPE	NO. BITS	POCC PROCESSING REQUIREMENTS		POCC DISPLAY REQUIREMENTS	
						DELAY TIME	PROCESSING REQUIREMENTS	DISPLAY DEVICE	FORMAT/TEXT
19.	ST-1	ECOC	1/4	A/S	13	RT			
20.	ST-2	ECOC	1/4	A/S	13	RT			
21.	ST-3	ECOC	1/4	A/S	13	RT			
22.	ST-4	ECOC	1/4	A/S	13	RT			
23.	ST-5	ECOC	1/4	A/S	13	RT			
24.	ST-6	ECOC	1/4	A/S	13	RT			
25.	ST-7	ECOC	1/4	A/S	13	RT			
26.	ST-8	ECOC	1/4	A/S	13	RT			
27.	ST-9	ECOC	1/4	A/S	13	RT			
28.	ST-10	ECOC	1/4	A/S	13	RT			
29.	ST-11	ECOC	1/4	A/S	13	RT			
30.	ST-12	ECOC	1/4	A/S	13	RT			
31.	ST-13	ECOC	1/4	A/S	13	RT			
32.	ST-14	ECOC	1/4	A/S	13	RT			
33.	ST-15	ECOC	1/4	A/S	13	RT			
34.	ST-16	ECOC	1/4	A/S	13	RT			
35.	A1	ECOC	1	A/S	13	RT			

TABLE B11-080.1 (Continued)

POCC TELEMETRY PROCESSING FOR EXPERIMENT 1NA008

ID	DESCRIPTION	CHANNEL	SPS	TYPE	NO. BITS	POCC PROCESSING REQUIREMENTS		POCC DISPLAY REQUIREMENTS	
						DELAY TIME	PROCESSING REQUIREMENTS	DISPLAY DEVICE	FORMAT/TEXT
36.	A2	ECOC	1	A/S	13	RT			
37.	A3	ECOC	1	A/S	13	RT			

APPENDIX L

CIS TO POCC COMPUTER INTERFACE RECOMMENDATIONS

(TBS)

APPENDIX M

POCC OD RELATED DATA
INTERFACE RECOMMENDATIONS
(TBS)

DOCUMF ?ISTRIBUTION LIST   MAR 1979

TITLE: JSC12033   SPACELAB DWNLNK AND DECOM ANAL.

AUTHORITY: A2E29   DRL: 5   TYPE: 2   FREQUENCY: AR

SISO RESPONSIBILITY: 2720   NASA RESPONSIBILITY: FS22

AHR, H.A.	IBM	MC51	1
BRADFORD, K.	IBM	MC79	1
BROOKS, C.	IBM	MC99	1
EVANS, G.H.	IBM	MC17	1
GRIFFIN, D.	IBM	MC69	1
HULEN, H.	IBM	MC99	1
MORGAN, R.	IBM	MC99	1
OLIN, R.G.	IBM	MC99	1
WICKLINE, A.	IBM	MC99	1
LO, L. DR.	MDTSCO	MDTSCO	1
DALTON, R.	NASA/GSFC	812	1
KELLY, A.	NASA/GSFC	562	1
PASHBY, P.	NASA/GSFC	816	1
UNDERWOOD, T.	NASA/GSFC	812.3	1
BATSON, B.H. DR.	NASA/JSC	EJ2	1
BLACKMER, S.M.	NASA/JSC	PH	1
BOYKIN, W.R.	NASA/JSC	SC4	1
BRANDENBURG, J.R.	NASA/JSC	FS45	1
BRISCOE, A.L.	NASA/JSC	CF7	1
BROOKS, M.F.	NASA/JSC	CA	1
CHASE, W.R.	NASA/JSC	LO	1
COLE, R.W.	NASA/JSC	FS47	1
CRANSFORD, C.L.	NASA/JSC	CG6	1
EGGLESTON, T.W.	NASA/JSC	EJ2	1
GOODSON, F.D.	NASA/JSC	JM61	3
HAGAN, M.	NASA/JSC	CH6	1
HALL, J.L.	NASA/JSC	FS5	1
HECTOR, G.D.	NASA/JSC	FS47	1
JOHNSON, A.R.	NASA/JSC	CH6	1
KUNDEL, K.K.	NASA/JSC	CH5	1
LLEWELLYN, J.S.	NASA/JSC	PF	1
LOREE, M.R.	NASA/JSC	FS51	9
MAYES, R.J.	NASA/JSC	FS53	1
MILLER, J.A.	NASA/JSC	F3	1
MYERS, R.L.	NASA/JSC	CG3	1
PARKER, J.L.	NASA/JSC	FS55	1
PATTERSON, L.R.	NASA/JSC	FE2	4
RENICK, J.G.	NASA/JSC	CH5	1
ROBINSON, W.G.	NASA/JSC	FS47	1
ROUNDTREE, J.R.	NASA/JSC	FS53	1
SAULTZ, J.E.	NASA/JSC	CH5	1
SHANNON, J.D.	NASA/JSC	CH6	1
SISCO, L.F.	NASA/JSC	FS22	1
SMITH, J.R.	NASA/JSC	FS2	1
SPAULDING, R.R.	NASA/JSC	FS55	1
STEPHENSON, H.	NASA/JSC	FD2	1
STUART, T.A.	NASA/JSC	FS15	1
SULLIVAN, C.J.	NASA/JSC	FS25	1
TEASDALE, W.E.	NASA/JSC	EJ2	1
VANCE, J.D.	NASA/JSC	FS55	1
VANDERVORT, Q.J.	NASA/JSC	FS54	1
WILLIAMS, J.B.	NASA/JSC	FS22	1
WRINKLE, F.H.	NASA/JSC	FS53	1
YOUNG, D.A.	NASA/JSC	FS45	1
STRAITON, J.	NASA/KSC	NSDL-DED-3	1
LADNER, J.	NASA/MSFC	MSFC/EF-25	1
MCNEIR, A.	NASA/MSFC	EF25	7
COOPER, P.	ROCKWELL	ZC01	1
BORSCHE, J.F.	SISO	3/G	1
BURTON, N.R.	SISO	3/E	1
DATA SERVICES	SISO	1/111	2
DEGNER, A.H.	SISO	1/208	1
DORMAN, D.K.	SISO	3/F	1
GANTZ, R.E.	SISO	3/B	1
JAMES, J.L.	SISO	S4/3073	1
JOLLEY, H.W.	SISO	1/224	1
KANDEFER, F.A.	SISO	3/F	4
LAPIDUS, A.L.	SISO	3/F	1
LIEDER, C.T.	SISO	3/F	1
NOSSAMAN, G.O.	SISO	3/F	1 **
PATTERSON, A.A.	SISO	3/G	1
PUBLICATIONS	SISO	1/215	2
SCHULTZ, C.R.	SISO	S30/1047	1
SMITH, S.P.	SISO	3/G	1
STANLEY, S.M.	SISO	3/F	1
WILSON, B.P.	SISO	3/E	1
WILSON, W.K.	SISO	3/F	1

COG ENG **

RELEASED BY
SISO
DATA SERVICES
CR 3/23/79

COG ENG **   TOTAL COPIES: 101

APPROVED DDL ON FILE IN SISO DATA SERVICES